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THE EAST AFRICAN AGRICULTURAL JOURNAL

of

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ANZIBAR

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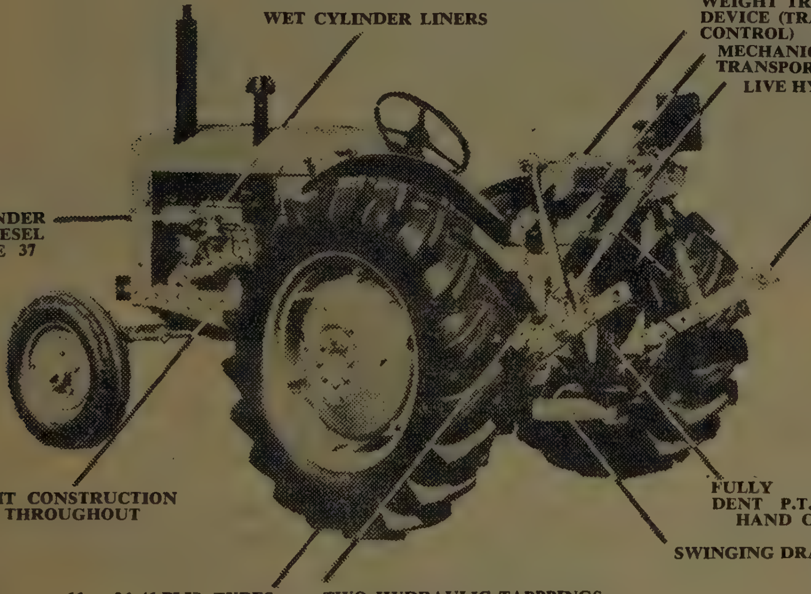
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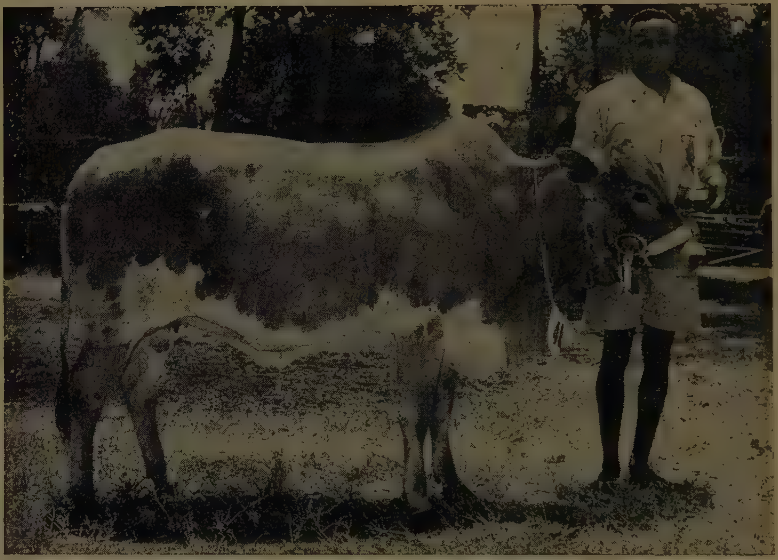

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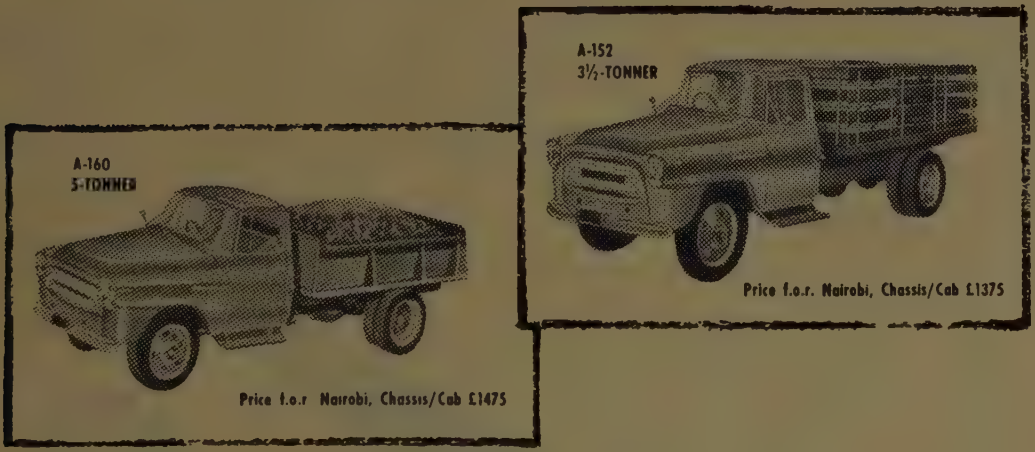
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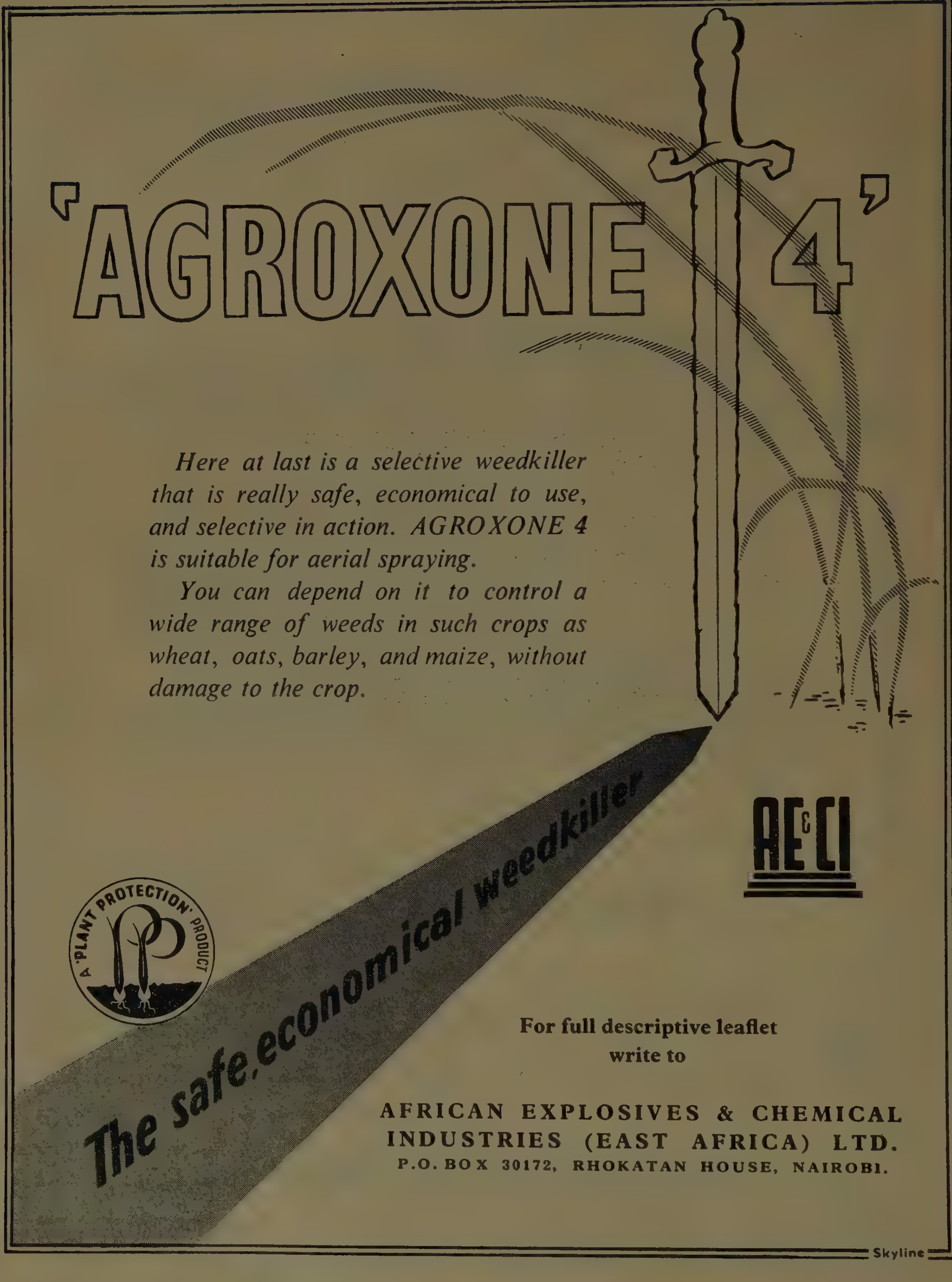

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THE EAST AFRICAN AGRICULTURAL JOURNAL

NOTES ON KENYA AGRICULTURE

III. OIL SEEDS, PULSES, LEGUMES, AND ROOT CROPS

By **A. H. Savile and W. A. Wright, Department of Agriculture, Kenya**

(*A table of seed rates, spacings, yields, etc., is given at the end of this article.*)

CASTOR (*Ricinus communis*)

Kiswahili—Mbarika

Climate and Soils

Requires warm climate, deep friable soil and moderate rainfall as for maize. Ample moisture important at planting time. Heavy rainfall and waterlogged soil must be avoided. Best soil is a rich well-drained sandy or clayey loam. Avoid loose, sandy or heavy clay and very acid soils. Often grows well in brackish soils. Excess of nitrogen causes exuberant vegetative growth at the cost of seed yields. Rainfall 20–35 in. Has a very wide altitude range.

Cultivation

Thorough deep preparation of the land is essential and early preparation affords birds opportunity to destroy insect pests in the ground, thereby reducing subsequent attacks on crop. Apply farmyard manure where soils are low in organic matter. This is an exhaustive crop which should not be grown as a pure stand more than once in five years on the same land. Pour boiling water on seed and leave to soak for 24 hours to promote even germination. If planted too close, branching will be restricted with consequent reduction in fruiting. Sow two to four seeds per hole and thin out to one sturdy seedling when 8–12 in. high. Keep well weeded till 2–3 ft. high and earth up round plants to prevent water collecting round stems. Tall, non-branching plants should be topped at 3 ft. to encourage branching and flowering. Often grown satisfactorily as a mixed crop with maize and pulses.

Harvesting

Care should be taken to prevent seed being scarified by grit from drying floors as this allows oil to exude which soon turns rancid thereby reducing the commercial value. African growers prefer the dehiscent type as it reduces the labour of threshing the crop. On a plantation scale the non-dehiscent type is preferable. It can be harvested, as and when labour is available, by using a jam tin with a slot cut in the side and can be threshed very easily with a suitable machine.

Major Uses

Oil is used as a lubricant in jet engines and in the manufacture of plastics. The bean consists of (1) a soft non-fibrous kernel containing approximately 62.9 per cent of oil, (2) a thin brittle seed coat, easily cracked or chipped in handling, containing approximately 10 per cent oil.

GROUNDNUT (*Arachis hypogea*)

Kiswahili—Karanga

Climate and Soils

Requires a light, friable, well-cultivated soil, preferably containing lime. Avoid soils subject to waterlogging or soils that set hard when dry. Rainfall 25–40 in.

Cultivation

Planting distance may vary from 12 × 6 in. or even closer for bunch types to 24 × 15 in. for spreading types. Close spacing often reduces the incidence of "Rosette disease" which results in yellowing and stunting of the plants. Planting normally carried out on well-prepared ridges with three or more rows per ridge. Not infrequently interplanted with a grain crop with beneficial results to the grain crop. Responds well to phosphate, 100 lb. double superphosphate per acre often giving an economic return. Ridge cultivation of doubtful benefit as a rule.

Harvesting

Usually by hand, though a mechanical harvester invented and developed by the N.I.A.E. at Silsoe showed signs of promise for use on a plantation scale. Considerable losses can occur when lifting the crop in soils which have set hard. Drying the freshly lifted crop on tripods is of considerable benefit under peasant cultivation as it usually results in much higher germination capacity.

Major Uses

The shelled nuts (kernels) are used for edible and culinary purposes. The kernels contain about 45 per cent oil which is used in the manufacture of margarine, salad oil, soap, cold cream, etc. After expression, the residual cake forms a valuable cattle fodder or fertilizer but will not store satisfactorily in hot, humid climates.

LINSEED (*Linum usitatissimum*)

Kiswahili—Kitani

Climate and Soils

This crop is suitable for the higher altitudes, 6,000–8,000 ft. It thrives on medium to heavy land provided a fine tilth can be obtained on the latter.

Cultivation

Deep cultivation is not necessary, but a firm seed-bed and a fine tilth are essential. Clean land is important because the plant is surface rooting and inter-row cultivation would be harmful. A light hand-weeding should be sufficient in the crop. Drill not more than ½ in. deep.

Harvesting

As the crop ripens unevenly if the stand is poor and the tough straw wraps itself round the working parts of machinery, harvesting by combine is often difficult. It is often preferable to pull by hand, stand until dry, cart, and thresh. Threshing with a high-speed beater drum better than with a peg drum.

Major Uses

Grown for oil which has many uses in industry. Linseed cake, obtained after the expression of the oil, is a highly valued concentrate for livestock.

NIGER SEED (*Guizotia abyssinica*)

Climate and Soils

This crop is suited to medium to high altitudes, the best range being 6,000–8,000 ft. However, satisfactory yields have been obtained at considerably lower altitudes. It is not exacting in its soil requirements, thriving on sandy loams to heavy soils. The crop requires good moisture conditions in its first two months of growth.

Cultivation

A clean, fine seed-bed, well compacted, is required. If seed is broadcast, cover with a light harrowing. Very little subsequent weeding should be necessary if the seed-bed has been well prepared.

Harvesting

This can be done either by machine or by hand. The crop is allowed to stand until the majority of the blossoms have withered. Further delay will cause very heavy seed loss through shedding. In harvesting by hand, cut the crop near the base, tie into bundles, and dry for a week or more. During this time some of the late-formed seed will mature.

Major Uses

Mainly used as an edible oil, and to some extent as a lubricant, and in the manufacture of soap. The residual press cake is a valuable cattle feed.

SUNFLOWER (*Helianthus annuus*)

Climate and Soils

Thrives in ordinary good soil in a warm and moderately moist climate. Altitude range is from medium to high. The crop flowers prematurely in tropical lowlands. Does not thrive in acid or waterlogged soils. Highly fertile soils may cause lodging and late ripening.

Cultivation

Prepare as for maize. Wide spacings should be avoided as the heads will then tend to be top-heavy and fall over. Weeding is necessary in the early stages of growth.

Harvesting

The leaves may still be green when the head is ripe. The browning of the florets on the face of the flower-head is the surest sign of ripening. The backs of the heads turn from green to yellow at the same time. Cut heads as they become ready in small areas, and when the majority of heads are ready in large areas. In damp conditions, cut the heads with some stalk and stook. Small quantities can be trashed by rubbing heads on small-mesh expanded metal nailed to board.

Major Uses

The crop is grown for its edible oil, whilst the cake left after expression of the oil makes an excellent concentrate for cattle. It is also used extensively as a silage crop and for green manuring.

SESAME (*Sesamum indicum*) Kiswahili—Ufuta

Climate and Soils

Thrives in a light, friable, well-drained soil with moderate rainfall in a warm or tropical climate. Avoid acid soils.

Cultivation

White-seeded varieties produce the best oil. Land should be well cultivated. Seed sown broadcast or in drills 1½ ft. apart.

Harvesting

When nearly ripe the crop is cut, tied in bundles and stooked. If allowed to ripen fully before cutting, seed will be lost by shattering. With normal yield of seed the crop produces about 10 gallons of oil per acre.

Major Uses

Oil content of seed is 45–50 per cent. Used for cooking, lighting, medicinal and various domestic purposes; also for salad oil, margarine, soap making. The cake residue after expression of the oil is a valuable cattle feed.

BONAVIST BEAN (*Dolichos lablab*) Kiswahili—Fiwi

Climate and Soils

Low to medium altitude with 20–45-in. rainfall. Thrives on rich soils of medium texture but does not withstand brackish or waterlogged conditions.

Cultivation

As for maize. Good seed-bed necessary. Should precede cereal crop in rotation.

Harvesting

By hand before oldest pods shatter. Threshed by hand as a rule.

Major Uses

Useful as food crop in areas of low to moderate rainfall, as cover crop to smother weeds, and for hay or fodder.

FRENCH AND HARICOT BEANS (*Phaseolus vulgaris*) Kiswahili—Maharage

Climate and Soils

Low to medium altitudes on loamy soils. 25–35-in. rainfall with moderately high temperatures. Avoid brackish or waterlogged soils.

Cultivation

Normal cultivation as for maize. Good, clean seed-bed is essential. Should precede cereal crop in rotation. 100 lb. double superphosphate often worth while. Can be undersown in bananas without detriment in areas of high rainfall.

Harvesting

By hand. Usually threshed by hand owing to damage by machine thresher.

Major Uses

Staple pulse throughout African areas and for employed labour.

LIMA OR MADAGASCAR BUTTER BEAN (*Phaseolatus lunatus*) Kiswahili—Maharage

Climate and Soils

As for French beans.

Cultivation

As for French beans.

Harvesting

By hand.

Major Uses

White-skinned varieties used for human consumption. Coloured varieties have been found to contain prussic acid in dangerous quantities and should be boiled twice in fresh water before final cooking.

SOYA BEAN (*Glycine max.*)

Climate and Soils

To ensure good yields, select variety suited to local conditions. In absence of such knowledge, cowpea is a safer crop except where it is prone to rust attack. Intolerant of acid soils (as is cowpea). Thrives on soils of average fertility, preferably deep loams and red volcanic soils. Less resistant to drought than cowpea. Altitude 2,000–5,000 ft. above sea level. Rainfall 30–50 in.

Cultivation

As for maize. Time sowing so that crop matures in dry season to reduce risk of moulds attacking pods. Can be sown with maize or sorghum for silage. Seed inoculation may be necessary to obtain best results. Seed rate varies a great deal as seed varies in size from 1,500 to 10,000 seeds per lb.

Harvesting

By mower for hay (1–2 tons per acre). Beware of heating in swathe or stack. Handle carefully to reduce loss of leaf. For grain harvest just before first pods are ready to shatter. Some varieties shatter more readily than others. Usually cut with mower and stooked till really to put through thresher. Resistant to weevil attack in storage.

Major Uses

Beans for human consumption, green manure, green fodder, hay and silage. Soya bean meal is valuable stock feed. Soya bean oil has various industrial uses.

SWORD BEAN (*Canavalia ensiformis*) = white seeded

JACK BEAN (*Canavalia gladiata*) = dark red seeded Kiswahili—Magobi, Mpupu

Climate and Soils

Seldom grown in Kenya. Requires high temperature and rainfall and good soils. It is slow maturing compared to cow pea and seldom worth the extra labour involved in cultivation and harvesting.

Cultivation

Climbing types have to be staked, which is unnecessary with bush variety. Cultivation and seed-bed as for French beans.

Harvesting

The large, flat pods are harvested by hand. Avoid the hairy-podded types as the hairs are liable to cause irritation.

Major Uses

When young, the seeds may be peeled and used as a substitute for broad-beans. When young and tender, the pods may be sliced and boiled as for green-beans.

TEPARY BEAN (*Phaseolus acutifolius*)

Climate and Soils

Suited to medium and heavy soils with 30–40 in. rainfall and medium elevations. Best yields obtained under irrigation.

Cultivation

As for French beans.

Harvesting

By hand.

Major Uses

Human consumption.

VELVET BEAN (*Stizolobium niveum*)

Climate and Soils

Rainfall 25–60 in. Altitude sea level to 7,000 ft. Tolerates an appreciable degree of soil acidity. Will thrive on a wide range of soils, even poor sands.

Cultivation

Well prepared as for maize. Keep weeded until crop covers the ground. Slower growing than cow pea but produces much denser cover over a longer period. Clean, weed-free seed bed essential owing to slower growth. When grown for silage with maize, grow each crop separately and mix when making silage as velvet bean tends to pull over maize plants. Except on newly-broken land, can be planted very successfully by sowing seed in alternate plough furrows.

Harvesting

By hand for beans and by mower for silage.

Major Uses

Useful for stock and human food. A good substitute for broad-beans if young beans are skinned. A very useful cover and green manure crop, especially in rotation with maize. Can be used for the suppression of *Cyperus* spp. and *Imperata cylindrica*. A useful fodder crop which can be interplanted late in maize. Useful soil improver on newly-broken land.

KENYA WILD WHITE CLOVER (*Trifolium semipilosum*)

Climate and Soils

Suited to wide range of soils above 7,000 ft., and found naturally in many areas. 36-in. minimum rainfall per annum.

Cultivation

Sown broadcast at rate 2 lb. per acre mixed with grass seed for leys. Fertilizers not normally required, but in parts of Uasin Gishu has responded well to 1½ cwt. gypsum per acre plus 1 cwt. double superphosphate.

Harvesting

Grazed.

Major Uses

Valuable nitrifying clover. Very palatable addition to grass leys.

LUCERNE (*Medicago sativa*)

Climate and Soils

Requires a deep, well-drained loam soil of medium to good fertility, neutral or slightly alkaline containing a fair amount of lime if possible. It is intolerant of brackish conditions when young. It is best suited to semi-arid conditions where competition from weeds and risk of disease is less. Under irrigation can be grown successfully as low as 1,550 ft. above sea level, but normal range is 6,000–8,500 ft.

Cultivation

Unable to compete with weed growth and vigorous grasses, and requires high standard of cultivation and very fine seed-bed. Use Cambridge roller after drilling to promote even, rapid germination. Inter-row weeding essential during establishment and after successive cuttings. Crop should last 20 years if carefully established and kept free from weed competition. Apply manure to previous cleaning crop rather than to the lucerne. At low altitudes crowns tend to become woody and should be broken up with a light disc. Can withstand dry periods owing to deep root system, but yield will be reduced.

Harvesting

By mower when 10 per cent of the stand is in bloom as there will be less loss of leaves.

Major Uses

Invaluable hay and fodder crop owing to high protein content of leaves (22 per cent compared to 8 per cent in stalks).

LUPINS (*Lupinus* spp.)

Climate and Soils

Rainfall should exceed 36 in. per annum. Medium to rich soil required. Altitude range from 9,000 ft. down to 7,500 ft. for sweet lupins and 6,500 ft. for bitter lupins.

Cultivation

Requires normal standard of cultivation and seed-bed. Apply 100 lb. double superphosphate per acre. Row crop or hand-weeding essential until plants are 18 in. high.

Harvesting

Usually by hand as seed harvested by combine tends to shatter. Often pulled and dried in field and then threshed by combine.

Major Uses

Can be used as human foodstuff. Valuable as high-protein concentrate in production ration for dairy cows.

CHICK PEA (*Cicer arientum*)

Kiswahili—Mdengu

Climate and Soils

Thrives on loamy to clay soils, with rainfall 20–35 in. and at altitudes from 1,000–4,000 ft. above sea level.

Cultivation

Normal preparation and weeding.

Harvesting

By hand.

Major Uses

A nutritious food, usually roasted whole or ground into flour.

COWPEA (*Vigna catiang*) Kiswahili—Kunde

Climate and Soils

Suited to low altitudes with rainfall 25–35 in. Suited to light and medium soils of moderate to good fertility.

Cultivation

As for French beans, etc. Preferable to sow towards end of heavy rainy season so that flowering takes place during light rainy weather. Often interplanted with sorghum or maize without detriment to grain crop. After harvesting may profitably be left as green cover crop on ground if not required as stock feed.

Harvesting

By hand.

Major Uses

Valuable as pulse for human consumption, hay for livestock and cover crop during part of dry season, e.g. between sisal rows.

PEAS (*Pisum sativum*) Kiswahili—Njegere

Climate and Soils

35–45-in. rainfall at 6,000 ft. upwards on medium to rich loamy soils.

Cultivation

High standard of cultivation to suppress weeds and a fine seed-bed to obtain rapid germination. Inter-row weeding as necessary. If broadcast, one hand-weeding to destroy major weeds. Respond to F.Y.M. and 100–200 lb. double superphosphate.

Harvesting

Pulled by hand, dried in the field and threshed in a combine.

Major Uses

Canning industry, mixed with oats as fodder or silage crop.

PIGEON PEA (*Cajanus indicus*)

Climate and Soils

With its strong tap root and vigorous root system, can be grown on a wide range of soils, particularly heavy soils of low fertility, but is susceptible to waterlogging. Rainfall 20–35 in. Altitude 0–4,500 ft.

Cultivation

Often interplanted with sorghum or grown along field boundaries. As a pure crop it is a good soil restorer and can form a useful windbreak when sown in narrow strips. Withstands drought well. Will last for two years. Cut back after harvest when succeeding crop will often outyield first crop.

Harvesting

By hand. Pick as soon as ripe and store carefully as it is readily attacked by weevils. To prepare "split peas" or "lentils" the seeds are soaked in sesame oil to soften seed coat and then lightly pounded in a mortar.

Major Uses

Split peas or lentils. Useful food crop in seasons of low rainfall. A useful windbreak effect in narrow strips across fields. Pods and leaves constitute an excellent fodder, and plants may also be used for browsing by stock. Large-seeded late varieties usually used for human consumption and small-seeded early types for fodder.

GRAMS

GREEN (*Phaseolus Mungo* var. *radiatus*)

Kiswahili—Choroko

BLACK (*Phaseolus Mungo*)

Kiswahili—Choroko

Climate and Soils

Suited to dry areas with rainfall up to 35 in. per annum. Thrives on medium to heavy plains soils at altitudes up to 5,000 ft.

Cultivation

As for French beans. May be grown pure or intercropped. Useful cash crop in low rainfall areas.

Harvesting

Plants cut, stacked to dry and threshed by hand.

Major Uses

A staple food for Asians, and liked by Africans also. Seeds as a vegetable or ground into flour and made into "popadams" and bread. Used to some extent as fodder and green manure.

BAMBARRA GROUNDNUT (*Voandzeia subterranea*)

Kiswahili—Njugu mawe

Climate and Soils

Altitude sea level to 5,000 ft. Generally grown in areas of well-distributed rainfall, 30–70 in., on sandy soils often of low fertility, but does best in a hot climate on sandy soils or sandy loams with a fair amount of lime and organic matter.

Cultivation

Normally grown as a pure stand. A well-prepared, deep, friable seed-bed is required to enable the plant to bury its seed pods after fertilization of the flowers. Often grown in rotation with maize and sorghum.

Harvesting

Plants are pulled and dried before removing the "nuts".

Major Uses

Human food.

CASSAVA (*Manihot utilissima*)

Kiswahili—Muhogo

Climate and Soils

A useful crop in sandy soils of low to moderate fertility and where rainfall is uncertain. Avoid heavy soils as these restrict development of tubers. Altitude 0–5,000 ft.

Cultivation

Generally best to plant on ridges, preferably 5 ft. wide by 3 ft. high, in order to encourage tuber development. Planted by means of 12-in. cuttings. To avoid serious losses from termites, plant only when soil is moist to a satisfactory depth.

Harvesting

Depending on variety, the crop can be lifted in from 6–12 months. Some varieties can be left in the ground for as long as three years, but majority deteriorate after 15 months. In Tanganyika, a variety known as *Akiba si mbaya,* which is a natural cross with Ceara rubber, does not form tubers for four years but these will keep in the ground for a further six years. There are two main types—bitter and sweet. The former are resistant to attacks by pigs and porcupine owing to their bitterness, due to the presence of prussic acid in the region of the skin. They require to be boiled twice in order to remove the prussic acid present in them. Bitter varieties, which are pig-proof, when grown on granitic soils, have been known to lose their bitterness and pig-proof quality when grown on "coral rag" soils at the Coast. Where pig are a serious menace at the Coast the best course is either to establish a very deep-rooting variety such as *Akiba si Mbaya* or to construct a pig-proof ditch or fence, without which it may be impossible to establish the crop.

Major Uses

It is a valuable drought-resistant crop which produces a heavy yield of starchy food, as do other root crops. This is no reason why its cultivation should be discouraged, since it is often sounder economics for African cultivators to be sure of a bulk food crop and purchase the additions needed for a balanced diet than risk having to pay famine prices for imported cereals after their own crops have failed.

IRISH POTATOES (*Solanum tuberosum*)

Kiswahili—Viazi vya ulaya

Climate and Soils

Can be grown at altitudes from 2,000–7,000 ft. Requires a light, friable, moist loam or gently sloping ground with good natural drainage and moderately dry climate. The ground should be well dressed with farmyard manure.

Cultivation

Avoid growing successive crops of potatoes on the same land in order to reduce risk of pests and diseases. Avoid growing the crop during prolonged wet, cloudy weather. "Seed" potatoes should be sprouted prior to planting. This is done by spreading them out in a thin layer in a cool, dark, dry place and covering them with straw. The land should be well ploughed and harrowed to a good depth about four weeks before planting and then allowed to settle so that it is not in too light a condition. Prior to planting, the land should be lightly ridged with ridges 2 ft. apart and the sprouted seed planted 12–14 in. apart in the furrows, in which F.Y.M. (and fertilizer) has already been placed. Where tractor-mounted spraying equipment may be available for subsequent disease control measures, it is important that the furrow widths should be kept constant and should match the distance between the tractor wheels. To control "Late Blight" (*Phytophthora infestans*) spray with Bordeaux mixture or colloidal copper compound when first two leaves are formed. Repeat twice at intervals of a fortnight. Potatoes can be grown satisfactorily under irrigation at low altitudes during the dry, cool season after the long rains.

Harvesting

Rogue out all plants which are not true to type before the crop starts withering. The crop should be handled carefully when harvesting. After exposure to the sun for an hour, the crop should be gathered into boxes and taken to a shed for storage prior to marketing.

SWEET POTATO (*Ipomea batatas*)

Kiswahili—Viazi vitamu.

Creeping perennial producing succulent tubers. Altitude 0–6,000 ft. Useful as an anti-famine crop and for opening up new land. Planted on ridges 3 ft. apart by means of 12-in. cuttings, preferably during cloudy weather.

Crop matures in 4–6 months. Yields 2–4 tons per acre. Wide range of varieties, usually white fleshed. A very good yellow-fleshed variety is "Caroline Lea", which is excellent when sliced and fried.

EDDO OR TARO (*Colocasia antiquorum*)

Kiswahili—Viazi vikuu

Tuberous herbaceous perennial, with large arrow-shaped leaves. Grown in most soils adjacent to swamps. In dry areas responds well to irrigation. Tubers produce vegetable similar to artichokes, and make excellent soup and food for invalids.

Planting distance 2 ft. × 2½ ft. to 3 ft. × 3 ft. Crop matures in 6–12 months and yields 2–5 tons per acre. Altitude 0–6,000 ft.

YAMS (*Dioscorea* sp.) Kiswahili—Viazi vikuu

Climbing plants with 3–6-veined leaves and large underground tubers. Thrive best in loose, deep soil at altitudes up to 4,000 ft. Usually planted on mounds, the vines being trained on stakes. Planting distance 2–3 ft. × 3–4 ft.

Plant portion of tuber containing three eyes. Crop matures in nine months, i.e. when stems die down. Yield 4–8 tons yer acre. Tubers store well.

Crop	Spacing	Seed Rate	Yield per Acre	Time to Maturity
Oil Seeds				
CASTOR—				
Small seeded	3′x1½′	14 lb.	900–1,500 lb. pure	4–5 months
Large seeded	6′x6′	10 lb.	250 lb. mixed	7–10 months
GROUNDNUT—				
Bunch	1′x6″	60–65 lb.	1,000–1,500 lb. (unshelled)	3½ months
Spreading	2′x1¼′	40 lb.		5 months
LINSEED	Broadcast or 7″ drills ½″ depth	45–55 lb.	400–1,600 lb.	4½ months
NIGER SEED	Broadcast or drill 18″ rows	10 lb. 5 lb.	600 lb.	4½ months
SUNFLOWER—				
Dwarf	1′–2′x1′–½′	20 lb.	700–1,000 lb.	3–5 months
Giant	3′–3½′x2′–1′	10 lb.		4–6 months
SESAME	Broadcast or drilled in rows 1½′ apart	8–10 lb.	400–600 lb.	4 months
Pulses and Legumes				
BEANS—				
Bonavist	2½′x3½′	20–30 lb.	400 lb.	3½ months
French	2′x1′	25 lb.	300–1,000 lb.	3 months
Haricot	2′x1′	25 lb.	300–1,000 lb.	3 months
Lima	2½′x1′	45–75 lb.	Up to 1,500 lb.	4½ months
Soya	2′x1′	20–30 lb.	800–900 lb.	4½ months
Sword	3′x1′ or Broadcast	70–150 lb.	800–1,000 lb.	4½ months
Tepary	2′x1′	15–20 lb.	450–1,500 lb.	3½ months
Velvet—Seed	2½′x2½′	25 lb.	500–600 lb.	4–6 months
—Green manure	Broadcast	50–100 lb.	6–9 tons	3–3½ months
CLOVERS	Broadcast or drill	2–4 lb.	—	—
LUCERNE	Drill 7″ rows	5–20 lb.	4 tons (green)	—
LUPINS—				
Bitter	Broadcast or drill up to 2′ rows for seed	80 lb.	800 lb.	3½ months
Sweet		100 lb.	1,000 lb.	5½ months
PEAS—				
Chick	1′x1′	30 lb.	500–650 lb.	3 months
Cow	1½′x1½′	20 lb.	500–650 lb.	3 months
Field	Broadcast or 7″ drills	120 lb.	2 tons hay 400 lb. seed	4½ months
Garden	2′x4′	80 lb.	Up to 600 lb.	4½ months
Pigeon:				
Seed	5′x4′	6 lb.	500–600 lb.	6 months
Cover or fodder	3′x1′	20 lb.	—	—
Green manure	Broadcast	50 lb.	—	—
GRAMS	1½′x6″	10–15 lb.	500–600 lb.	3 months
BAMBARRA GROUNDNUT	1½′x1½′	25 lb.	600–800 lb.	4 months
Root Crops				
CASSAVA	5′x4′	Cuttings	3–8 tons	9–24 months
POTATOES—				
Irish	2′x1′	8 cwt.	3–8 tons	4–5 months
Sweet	3′x1¼′	15,000 slips	2–4 tons	4–6 months
YAMS	3½′x2½′	Eyed portion of tuber	4–8 tons	9 months
EDDO OR TARO	3′x2′	Tubers	2–5 tons	6–12 months

FARM PREPARATION OF A DRIED SKIM-MILK FEED

By **D. L. Brown, Egerton Agricultural College, Njoro, Kenya**

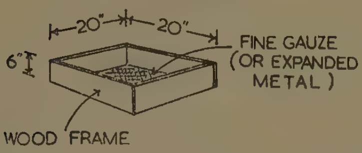
(Received for publication on 20th January, 1958)

Owing to the high cost of animal protein feeds in Kenya and to the fact that surplus skim-milk is usually fed at levels which permit a great deal of wastage, the procedure indicated below was carried out on a trial basis at the Egerton Agricultural College. The method allows a relatively cheap conversion of surplus skim-milk into dry material which can then be incorporated into a concentrate mixture, and thus provide a high quality protein supplement for pigs and poultry. This paper is concerned with the technique and the protein values of the material, prepared firstly in an oven and secondly by using the heat of the sun. The latter, as it will be appreciated, is the method advocated for use on farms where surplus skim-milk is available for such conversion.

PROCEDURE

Fresh skim-milk, placed in clean 4-gallon kerosene tins, was allowed to "sour" at room temperature. The spongy curd which forms a layer on top of the whey after 2–4 days, depending on prevailing temperatures, was then removed and placed on the drying-sieve (*see* Fig. 1) and allowed to drain, and dry in the sun. The drying is best done using a drying table to minimize curd and whey loss (*see* Fig. 2). Two methods were tried in removing the curd, one by hand (this could be improved by attaching a tap to the tin and allowing the whey to drain off but without loss of curd), and the second by pouring into doubled cheese-cloth. The moisture could be removed by pressure on the contents, but a loss of some of the curd will result.

FIG. I DRYING-SIEVE DETAILS
(2½-3 GALLON CAPACITY)



When sufficiently dry, that is when the curd particles will not slip through the gauze, the curd should be turned over frequently until after about 3–4 days of sun-drying the granules should be dry enough to bag and store. The period of "safe" storage will be reported upon in a subsequent paper when feeding trials have been conducted.

The curd layer on the drying-sieve should not be too thick, otherwise drying will take longer—an important consideration during periods of rain. The thickness of this layer should not be more than about ½ in.

A modification of the above souring process is to use a "starter", which can be a small quantity of whey from previously soured milk. This will reduce the curd-forming time to about two days, depending on prevailing temperatures. The disadvantage of the latter method is that a "smoother" curd is usually obtained and the initial removal of whey from the curd has to be carried out by placing in several layers of cheese-cloth, and allowing the curd to drain by gravitation.

RESULTS AND CONCLUSIONS

The hard curd granules which, incidentally, when tasted, had a pleasant flavour, gave the following crude protein analysis:—

TABLE I

RESULTS OF CHEMICAL ANALYSIS FOR CRUDE PROTEIN

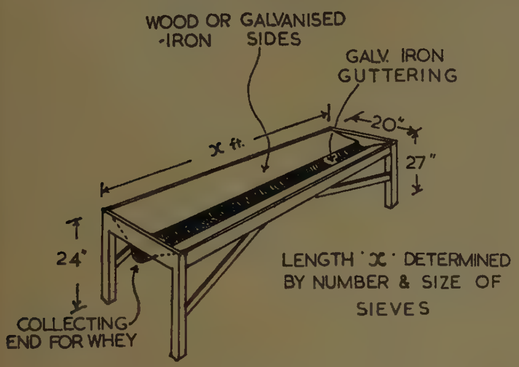
(mean of two analyses for each sample)

	Sample A (Oven-dried at ± 60°F for 4 days)	Sample B (Sun-dried for 3½ days*)
Moisture per cent.. ..	1·7	7·6
Crude Protein per cent .. (N x 6·38)	80·4	67·0

*Note that "ideal" weather (i.e. sunny and dry) prevailed throughout this period.

The oven-dried material yielded approximately 4.3 oz. solids per gallon of skim-milk, which gives a figure of about 2.7 per cent dry matter. This is very much less than half the figure that would be expected if all solids in the skim-milk were recoverable by this method. However, as long as the whey is not discarded, but fed to pigs, the minerals, water soluble vitamins, sugar and some protein, otherwise lost, can be utilized by the pig.

FIG. 2 A RECOMMENDED DRYING-TABLE


WOOD OR GALVANISED -IRON SIDES
GALV. IRON GUTTERING
20"
x ft.
27"
24"
LENGTH 'x' DETERMINED BY NUMBER & SIZE OF SIEVES
COLLECTING END FOR WHEY

The conclusions reached so far are that this method could be a boon to farmers possibly throughout the whole year, but especially during those periods when surplus skim-milk is available. However, the drying of the curd during the rainy season may have distinct difficulties, since drying will take longer and the period of storage will most certainly be reduced. Nevertheless, where portable tables and drying-racks can be constructed so that they can easily be placed under cover when rain threatens, and replaced when the sun shines, the product derived from this simple process, ground up, would be invaluable in the diet of pigs and poultry, especially when the biological value of caseinogen is rated at a higher level than either fish or meat meal. (Halnan and Garner, 1947.) It is suggested that the ground-up curd granules could be used in conjunction with a protein supplement like blood meal in view of the small amount of curd usually available.

SUMMARY

A method for the drying of part of the solids contained in skim-milk is outlined, and the results to date indicate that the sun-dried curd has a crude protein content of 67 per cent. It is recommended that the whey be fed in the usual way to pigs, and that the curd be ground prior to use in pig and poultry concentrate rations.

ACKNOWLEDGMENTS

The writer wishes to acknowledge the analyses carried out by Mr. Bagshaw, the Chemist at the College, and also Messrs. Schofield and Slowey for help in this project.

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THE EFFECT OF ENVIRONMENT ON INTERNAL EGG QUALITY

By **P. W. G. Lake, Department of Veterinary Services, Tanganyika**

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All poultry keepers must be fully aware of the importance of marketing high quality eggs. The presentation of a first class product not only simplifies the sale of that product but also increases public demand for it. A knowledge of the most important factors which affect the internal quality of eggs can assist the farmer in his efforts to produce a better article for sale.

First, it is necessary to understand the internal structure of a normal new-laid egg in order to appreciate more clearly how loss in quality occurs. The shell, which is the container for the egg contents, is coated with a waxy substance known as "bloom". This can be compared with a similar substance seen covering the surface of ripe fruit such as grapes and plums. The "bloom" tends to seal the pores and helps to reduce evaporation and the entry of putrefactive bacteria.

The shell is lined with two membranes or "skins". These membranes lie close together and only separate at the large end of the egg where they form the air space. During storage there is a loss of carbon dioxide and moisture from the egg and this results in the enlargement of the air space due to the contraction of the egg contents.

The egg albumen or "white" is in three layers, an outer thin layer, the inner thick layer, and between the two a more liquid middle thin layer.

The yolk is held in position in the centre of the egg by thick spirals of albumen which are rope-like in appearance and known as chalazae. These are attached to the yolk covering, or vitelline membrane, and to the inner shell membrane at the large and small ends of the egg. Suspended by the chalazae, the yolk in a new-laid egg is almost spherical in shape and should be an even orange-yellow colour. When broken out the yolk should stand well up from the white. A small lighter coloured spot will be seen on the surface; this is the "germinal disc", which in the fertile egg will, by a process of cell division, develop into the living chick.

The ideal temperature for egg storage whilst awaiting delivery to either the middleman or consumer is between 50° and 60° F. Deterioration in quality commences early and proceeds very rapidly if the eggs are held at high temperatures. It is, therefore, most important that eggs be cooled as quickly as possible, from the temperature at which they are laid to below 60° F.

The temperature of an egg when it is laid is 105° to 107° F. and experimental work has shown that it takes eight hours for an egg to cool from 100° F. to 60° F. when held at a room temperature of 50° F. This occurs when the eggs are placed in a wire basket, but eggs in a bucket take 18 hours to reach 60° F. under the same conditions. These facts emphasize the importance of frequent collections from the nest and immediate removal to a cool room. A further indication of the importance of rapid cooling and storage at a low temperature is given in the work of Sharp and Powell of Cornell University. These workers demonstrated that the time required for a drop in quality of new-laid eggs from U.S. Standard AA to B (stale) was:—

3 days at 98.6° F.

8 days at 77.0° F.

23 days at 60.8° F.

65 days at 44.6° F.

100 days at 37.6° F.

When an egg is stored at a high temperature the mucin fibres in the albumen break down and the "white" of the egg becomes more liquid. This has the effect of causing the white to spread over a wide area when the egg is broken out. In addition water passes from the middle thin white layer into the yolk and causes distension of the vitelline membrane and a flattening of the yolk when broken out. The yolk also fails to stand up from the white owing to the break-down of the inner thick layer of albumen. Carbon dioxide (which is beneficial to the egg) is lost through the shell pores. Rapid cooling slows down the speed at which this deterioration takes place.

Birds kept for the production of eating-eggs should not be mated, as fertile eggs commence development when stored at temperatures higher than 68° F. The subsequent death of the embryo accelerates decomposition. Broody hens in the nest boxes are a nuisance; they hoard the eggs, increase the incidence of breakages, and prevent the eggs from cooling.

When held at too low a humidity eggs develop a mottled appearance on the shell and, in serious cases, a ring is seen around the edge of the air space. Weak, very liquid albumen is the result of the evaporation of water from the egg. The rate of evaporation is increased in dry atmospheres, and the relative humidity should be 70 per cent or over in the egg-storage room.

Foodstuffs affect the shell and yolk only, and diets deficient in calcium or vitamin D will produce faulty shells. Certain ingredients affect yolk colour. A good yellowish-orange coloured yolk is desirable, as it increases the palatability of the egg; this colour is achieved in intensively-housed birds by the inclusion in the ration of good-quality lucerne meal or yellow maize.

These foodstuffs contain a pigment (xanthophyll) which is transmitted to the yolk and gives it colour. Certain undesirable fractions present in some plants produce abnormal colours in the yolks laid by birds consuming these plants. Pimento spice produces reddish yolks; cotton seed, acorns, "Shepherd's Purse" (*Capsella bursa pastoris*) and "Penny Cress" (*Thalaspi arvense*) produce olive-coloured yolks.

Unnecessary shaking and jolting loosens the firmness of the whites and yolk and may break the inner membrane of the air space and produce what is known as a "running air cell". In this condition air is in direct contact with the egg contents and rapid decomposition follows.

Sometimes faults can be found in eggs as soon as they are laid. Abnormalities such as blood and meat spots are not uncommon and are caused by small haemorrhages or ruptured tissue at the time of ovulation. Haemorrhages occurring in the oviduct cause blood to spread through the albumen and thus produce what are known as "bloody eggs". A deficiency of vitamin K or sudden frights can accentuate these faults, but they are normally hereditary.

Double-yolked eggs are not uncommon, especially in pullets just commencing to lay, although some adult hens occasionally produce this type of egg. They are troublesome as, being larger than others, they produce a problem when being packed into trays and boxes. They make the other eggs in the tray look small, and being higher in the tray than the rest, are more liable to be broken. This type of egg should be the poultry keeper's perquisite, and should be consumed at home.

The washing of dirty eggs improves their external appearance but endangers their keeping quality. Washing destroys the "bloom" of the egg and at the same time spreads the bacteria present in the manure and dirt over the shell, thus providing a greater surface area over which bacteria may enter the egg.

Research has been carried out into the use of certain solutions for washing eggs with a view to reducing the possibility of subsequent bacterial invasion. A solution of 1 per cent sodium hydroxide was claimed as effective. In America proprietary egg-washing solutions are sold and in Great Britain a detergent such as "Stanobrite" used as a ½ per cent solution is suggested. When eggs are immersed in one of these solutions the temperature of the solution must always be about 15° F. higher than the internal temperature of the egg. Water colder than the egg causes a contraction of the contents and in consequence some of the washing water is drawn into the egg through the pores. Eggs should not remain immersed for more than one minute.

Very fine cracks (hair cracks), which are only visible on candling the eggs with a strong light, endanger the internal quality of the egg as they provide an entry for putrefactive bacteria. They also endanger neighbouring eggs when packed into trays, as they are easily broken and the contents from the broken egg will soil near-by eggs. The contents of a broken egg will also rapidly putrefy in the tray, producing a foul odour which is liable to be absorbed by the other eggs.

The Practical Approach to Controlling These Factors

Eggs must be collected frequently, i.e. at least three times daily, and must be stored in a cool room with sufficient ventilation only to keep the air fresh. As rapid ventilation accelerates evaporation from the egg, windows or ventilators should be covered with open-weave hessian which should be kept wet during the dry season to main the humidity in the egg storage room and also to help keep it cool. If possible, the eggs should be stored at a temperature between 50° and 60° F. This can be achieved by constructing a small room on the principle of a charcoal cooler, which has walls of some porous material which are kept continually wet. In this way a high humidity and a lower than normal temperature can be maintained in the room.

Packing materials should also be stored in a cool place, as these are normally made of materials which are poor conductors of heat and do not quickly heat up when the eggs are packed for transportation to the consuming areas. Cool eggs packed into warm boxes often sweat, and this causes the shells to become stained and unsightly. Every endeavour should be made to despatch the eggs from the farm in good condition in order to offset the loss in quality which may occur between the farm and the time that the egg reaches the consumer. It is consumer demand, or lack of it, which determines the volume of sales that the producer can achieve.

Eggs absorb odours very readily and care should be exercised to avoid storing them in the presence of any strong smell. Likewise dirty packing material is most harmful in that it will impart an unpleasant flavour to the eggs as well as increase the risk of putrefaction.

Long, rough journeys should where possible be avoided. Prolonged shaking produces tremulous air cells or, even worse, "running" air cells, which hasten the decomposition of the eggs.

The production of dirty eggs must be avoided if possible. Nest boxes should be supplied with clean nesting material which should be frequently changed. Broodies must be removed immediately they are detected in order to reduce the risk of eggs being broken in the nests. Nest boxes should be constructed at least one foot above the floor level thus avoiding the direct entry of soiled floor litter into the nests. In laying-batteries care should be taken to clean the cage floors at once should they become soiled. Accumulated feathers from moulting hens frequently block the spaces in the floor and allow manure to collect on top.

Hair cracks in the shells are easily overlooked unless the eggs are candled. There are various reasons for this fault, and the most frequent occurs when eggs are collected in buckets or deep narrow containers. If a bucket is filled with eggs and then lifted the sides tend to compress and place a pressure on the eggs. During hot weather hens naturally lay thinner-shelled eggs even when all the nutritional requirements are supplied to assure good shell formation. Thus, at these times, eggs are naturally more vulnerable and greater care should be taken. Hair cracks are also caused by infrequent egg collections from the nest and from severe jolting such as would occur on a long journey over corrugated roads in a heavy lorry.

Eggs should be consigned from the farm as frequently as is possible. This is particularly so when they are travelling from the comparative coolness of the Highlands to the Coast, thus allowing reasonable time for the eggs to be marketed to the consumer before serious loss in quality occurs.

Eggs are best consigned early in the week to avoid the inevitable delay over the weekend. Naturally, cost of transportation to the market must be considered, but broadly speaking, the method which enables the eggs to reach the customer in the shortest time with the minimum of rough handling is the most desirable. When packing eggs care should be taken to match up each tray-full as, even when the eggs have been graded, there is some variation in shape and colour. Abnormally shaped eggs detract from the appearance of a consignment.

When egg-producing farms are situated a long way from the markets the farmer should make every effort to deliver the eggs to the consumer in the best possible condition. This is most practicable if done through a co-operative society with a central marketing organization.

RELEASE OF NEW CEREAL VARIETIES—1958

By H. C. Thorpe and G. E. Dixon, Plant Breeding Station, Njoro, Kenya

(*Received for publication on 13th March, 1958*)

The following new cereal varieties have been released by the Department of Agriculture for the 1958 season.

WHEAT

Cross 339

A selection from the cross 192.Q.2.A(L) × Australian 37/2.5.4 developed at Njoro. It is a beardless, white-chaffed, white-grained variety of mid-season maturity and good straw strength. The baking quality is unfortunately poor. It has shown good field resistance to black stem rust, but is rather susceptible to yellow rust.

It is therefore recommended for the lowest wheat areas only and should not be grown above 6,500 feet.

362.B.1.A.2.

A further selection from the cross Equator × 294.M.7.C.6.A, developed at Molo. This is a beardless, red-chaffed variety of mid-season maturity, fair straw strength, red grain colour and poor baking quality. As is the case with the other strains of this cross already released (1957), it has shown some susceptibility to stem rust during its multiplication. However, since these varieties are high-altitude wheats it is hoped this will not prove a serious drawback.

The variety 362.B.1.A.2 shows resistance to yellow rust at the highest altitudes and, together with the other strains, is suited to areas above 8,000 feet.

367.AR.3.B.2.B.

A selection from the cross Australian Warigo × 184.P.2.A.1.F, developed at Njoro. It is a beardless, white-chaffed, red-grained variety of mid-season maturity, fair straw strength and fair baking quality. It possesses good resistance to stem rust but has been slightly attacked in the field during multiplication.

This wheat is suited to 6,000–7,000 feet, but should not be grown above this altitude due to its susceptibility to yellow rust.

367.BR.1.D.4.B.

A second selection from the cross Australian Warigo × 184.P.2.A.1.F, developed at Njoro. It differs in having white instead of red grain, and shows rather less resistance to yellow ear rust although possibly more to black stem rust.

This wheat has done well in the Rongai valley and is suited to the 6,000–6,500 feet altitude range.

H.462.A-3-4.2.3.

A direct importation from the United States of America, where it was derived from the cross Fontana × Thatcher-W38-Hope. It is a bearded, white-chaffed variety of early season maturity, red grain colour and moderate baking quality. The straw is of fair strength. H.462 has done well in the Rongai valley, at Naro Moru, and in the Northern Province of Tanganyika. It had shown complete stem rust resistance in the field during multiplication but rust has appeared on current crops at Naro Moru and in Tanganyika.

H.462 is suited to the 6,000–7,000 feet altitude range and should provide a useful variety for districts requiring quick maturity.

R.L.2150/A.

A single plant selection from the Canadian variety R.L.2150 which derives from the cross Marquis^2 × *Agropyron elongatum*. This is a beardless, white-chaffed, red-grained variety of mid-season maturity, fair straw strength and good baking quality. It has shown fair resistance to stem rust, but has proved susceptible in the lower areas to brown leaf rust.

It is suitable only for areas from 6,500-7,500 ft.

Sabanero/1.

A fresh selection developed at Njoro, from the parent variety Sabanero.

This selection is suited to all areas in which Sabanero can be grown successfully (6,000–8,500 feet) and provides a pure source of seed.

BARLEY

Research (*Mid-season*)

A selection developed in New Zealand from the parent variety Research. Research itself was released to farmers in 1948.

Mid-season Research has yielded well on a field scale, and is of rather better straw than the parent variety. It is suited to all areas in which Research is grown satisfactorily (6,000–9,000 feet). For malting purposes the plumpest samples are likely to be produced in the high country under cooler, longer-season conditions.

REFERENCE

"Release of New Cereal Varieties—1957" by H. C. Thorpe and G. E. Dixon, E.A.A.J. Vol. XXII, No. 4, April, 1957.

THE USE OF DIELDRIN FOR CONTROL OF CARPENTER BEES (XYLOCOPA SP.)

By **Paul E. S. Whalley, Department of Agriculture, Uganda**

(Received for publication on 1st March, 1958)

The large wood-boring bees of the genus *Xylocopa* cause considerable damage to timber by their tunnelling. The adult bees have well developed mandibles and make tunnels in which they store food (pollen) for the larvae. The bees are particularly partial to making their tunnels in the rafters of buildings. Since these tunnels may be from three-quarters of an inch to an inch in diameter and up to 12 inches long, a considerable amount of damage is done.

At Kawanda Research Station, near Kampala, the bees were doing considerable damage to the rafters of houses and laboratories. Two houses, built 20 years ago, had over 200 tunnels in the rafters of each house. The tunnels are generally made in unpainted wood although some damage has been found on painted wood.

Curry (1956) reports that control of *Xylocopa* has been achieved with lime whitewash and with 0.5 per cent Dieldrin, both treatments being effective for two months. At Kawanda, three concentrations of Dieldrin wettable powder were used, 1.0 per cent, 0.5 per cent and 0.25 per cent. Two houses were selected for the first trial. The rafters projecting round each house were sprayed to run off with a long lance on a Leo Colibri sprayer. One house was sprayed with four gallons of 1 per cent Dieldrin W.P. (House No. 10) at a cost of Sh. 16, the other was sprayed with two gallons of 1 per cent Dieldrin W.P. (House No. 9) costing Sh. 8 for the treatment. Two gallons were adequate to cover the rafters, in the former case each rafter was sprayed twice while in the latter case only one circuit of the house was made. Round the laboratories the rafters were sprayed with Dieldrin W.P. at 1.0 per cent, 0.5 per cent and 0.25 per cent concentrations.

Initially all the treatments were equally successful and complete cessation of all boring was observed. Over a 13-week period collections of dead insects were made every day below the rafters of the two houses.

It will be noticed that nearly twice as many dead insects were found round house No. 9. This is probably due to the fact that the ground is clear around this house while house No. 10 is surrounded by bushes, making searching more difficult. Over this 13-week period many other insects were killed by the Dieldrin. It was also noticed that Geckos were particularly susceptible to the insecticide during the first week after treatment.

Table I

Total number of *Xylocopa* spp. found over a 13-week period

Species	House No. 9	House No. 10
Xylocopa inconstans Sm.	6	0
X. flavorufa de G. ..	64	75
X. nigrita Fab.	93	73
X. olivacea Fab.	252	103
X. aenipennis Fab.	4	0
X. modesta Sm.	0	5

With the other treatments carried out on the rafters of the laboratories, collections were not made every day. After 3–4 months new borings were found in the wood treated with 0.25 per cent Dieldrin, but no new borings were found in the 0.5 per cent treatment for over six months. In the 1 per cent treatments of both the houses and the laboratories, kills of *Xylocopa* are still being recorded ten months after treatment.

SUMMARY

The effect of three concentrations of Dieldrin W.P. on *Xylocopa* spp. is given. A 1 per cent concentration was found to give protection for at least ten months.

ACKNOWLEDGMENTS

The assistance of Mr. T. R. Odhiambo in sorting the insect material and Messrs. Mabizzi and Omiat in making most of the field collections is acknowledged. The comments of the Senior Entomologist, Mr. J. Bowden, and Mr. J. C. Davies, on the draft are much appreciated. Permission to publish this note has been received from the Director of Agriculture, Uganda.

REFERENCES

Curry, S. J., 1957. Quarterly Report of the Forest Entomologist, Kenya, October. (Unpublished.)

THE CHEMICAL COMPOSITION OF THE GRASSES OF KENYA—I

By H. W. Dougall and A. V. Bogdan, The Grassland Research Station, Department of Agriculture, Kitale, Kenya

(Received for publication on 20th December, 1957)

There are more than 450 species of grass in Kenya. Over half of these occur in natural grassland, either as important components of the sward or as less significant admixtures; the remainder are found in forests, in swamps or as "weeds" of arable land. A number of the more important species are well known. These have been described by Edwards and Bogdan in their book *Important Grassland Plants of Kenya* [1]. In this book the authors were obliged to base their estimates of the value of most of the grasses on behaviour under grazing, palatability and persistence, not on chemical composition. Indeed, extraordinarily little is known about the chemical composition of the greater majority of Kenya grasses, and the few analytical data which do appear in the aforementioned book cannot validly be compared, since these refer to species which differ in the state of maturity at which they were examined.

In our nursery at Kitale there is a large, living museum of grasses which have been collected from widely divergent districts in Kenya for the purpose of studying their habits, biology, persistence, palatability and other important features. We considered that this material afforded us an excellent opportunity to contribute to the knowledge of the chemical composition of the grasses of Kenya, and that if we obtained samples at a specified stage of growth, i.e. the early-flowering stage, it would be permissible for us to make comparisons between species at a later date. We realize that the composition of each individual grass in its natural habitat may well be different from that which we find under our conditions of soil and climate at Kitale. On the other hand, the influence of environment on the chemical composition of each species is minimized or excluded from our results, and these latter in the main depend on the characteristics inherited by each species.

We present below, in alphabetical order, a brief description of 58 grasses together with a note on their distribution and on their probable value as food for livestock. The chemical composition of the grasses is appended. It is noteworthy that at the early-flowering stage of growth crude protein values range from 5 to 19 per cent of the dry matter; crude fibre values from 14 to 43 per cent; calcium from 0.09 to 0.55 per cent and phosphorus from 0.07 to 0.37 per cent.

Agrostis schimperiana Hochst. ex Steud.—A tufted perennial 1–2½ ft. in height which occurs in swamps at altitudes from 6,000 to 8,000 ft. where it usually forms low growth between larger tufts of coarse grasses and sedges. This grass is well grazed and it is under trial for cultivation on swampy ground. The feeding value of *A. schimperiana* is high, its crude protein content reaching 18 per cent, and it is not markedly fibrous.

Alloteropsis semialata (R. Br.) Hitchc.—A tufted perennial 9 in. to 18 in. in height which occurs in the grasslands of western Kenya. It is an early grass which flowers at the very beginning of the rains. Our sample of herbage from the nursery is rich in crude protein and phosphorus; it is not at all fibrous.

Andropogon chrysostachyus Steud.—A tufted perennial of medium size which occurs in the highland-grassland at altitudes over 7,000 ft. Although this grass is very fibrous, it is well liked by cattle. Our analyses show that its nutritive value is not high.

Andropogon distachyus L.—A tufted or slowly-spreading perennial which forms large colonies at 7,000 to 9,000 ft. altitude. It is common in the Thomson's Falls–Ol Kalou area. This grass is usually stemmy and very fibrous, and its feeding value is low.

Andropogon schinzii Hack.—A tufted perennial 1–3 ft. in height. It occurs at altitudes from 3,000 to 6,000 ft., often on rocky ground. This grass contains a fair amount of protein, but it is very fibrous.

Anthephora hochstetteri Nees.—A tufted perennial 2–5 ft. in height which occurs on rocky slopes in the West Suk District. The nutritive value of this grass, as judged on its crude protein content, is fairly good.

Aristida adoensis Hochst.—A tufted perennial 1–2 ft. in height which is common in overgrazed or mismanaged pastures at altitudes between 4,000 and 8,000 ft. Crude protein and crude fibre values indicate a grass of reasonable nutritive value. When this grass passes the flowering stage of growth it becomes unpalatable.

Arundinella nepalensis Trin.—A robust tufted perennial 3–6 ft. in height which occurs in swamps, mostly in the Nairobi–Thika area. It is a grass of low palatability.

Bothriochloa radicans (Lehm.) A. Camus.—A tufted perennial 6 in. to 2 ft. in height which forms low cushions. It is common in semi-arid areas, from 3,000 to 5,000 ft. altitude, mostly on rocky slopes in open grassland. *B. radicans* is well liked by all grazing animals. Our analyses show that it contains adequate amounts of crude protein and phosphorus and that it is not particularly fibrous.

Brachiaria decumbens Stapf.—A low-growing, spreading perennial with prostrate stems rooting from nodes and numerous short leaves. It occurs in the Nyanza Province, in wet places. The nutritive value of *B. decumbens* seems to be fairly high.

Brachiaria dictyoneura (Fig. et De Not.) Stapf.—A tufted perennial 1–2½ ft. in height which occurs at medium altitudes in grassland and in bush. Although this grass is grazed well, its nutritive value seems to be low, for it contains very little crude protein and it is very fibrous.

Brachiaria platynota (K. Schum.) Robyns.—A tufted perennial 1–2½ ft. in height which occurs in *Combretum-Hyparrhenia* woodland in tall *Hyparrhenia* sward. Our analyses indicate that this grass is of relatively low nutritive value.

Brachiaria serrata (Spreng.) Stapf.—A perennial forming low cushions on rocky slopes in semi-arid parts of Kenya. The nutritive value of this grass is low.

Cenchrus setigerus Vahl.—A tufted perennial 9 in. to 2½ ft. in height. It occurs in arid and semi-arid parts of Kenya and it is common in the Lake Magadi area. *C. setigerus* is under trial as a potential ley grass for dry, marginal areas. It is rich in crude protein and it is not particularly fibrous.

Cymbopogon afronardus Stapf.—A tall robust perennial common in the Nyanza Province where it covers large areas. This grass is not eaten by cattle and it is an undesirable component in pastures. Only its leaves were analysed, and these show the low nutritive value of the grass because of their high crude fibre and relatively low crude protein contents. *C. afronardus* is a slightly aromatic grass and it is not surprising that its "ether-extractives" are relatively high.

Cymbopogon giganteus (Hochst.) Chiov. A tufted perennial 5–8 ft. in height with thick stems which occurs in *Combretum-Hyparrhenia*-wooded grassland. This grass remains green for a long time and in the dry season it is well grazed if it is only thinly scattered amongst other grasses. The nutritive value of *C. giganteus* is low: its crude fibre content is high, and its crude protein content low. The leaves of *C. giganteus* are aromatic and have a characteristic "pepper" flavour.

Cymbopogon pospischilii (K. Schum.) C. E. Hubbard.—A tufted perennial 2–4 ft. in height. It is very common in the eastern part of Kenya at altitudes from 3,500 to 5,500 ft. and it is often a dominant grass in grassland with scattered trees in the *Acacia-Themeda* zone. This grass is eaten only when no other grazing is available and its content of crude protein is relatively low. *C. pospischilii* is slightly aromatic and its "ether extractives" are relatively high.

Cypholepis yemenica (Schweinf.) Chiov.—A tufted perennial 12–18 in. in height which occurs in arid and semi-arid areas, mostly on rocky ground. It may be a useful species for reseeding bare, rocky ground. Although rather stemmy, this grass is liked by grazing animals and its crude protein content is high.

Digitaria diagonalis (Nees) Stapf.—A tufted perennial which occurs mostly in the *Combretum-Hyparrhenia* zone in open grassland and in bush. It reaches 3 ft. in height. *D. diagonalis* is rather stemmy, and its crude protein content is low.

Digitaria gazensis Rendle.—A tufted perennial 1–2½ ft. in height which occurs under a wide range of conditions and is commonly found on waterlogged black clays. The feeding value of this grass is satisfactory. The crude protein content of our sample amounted to nearly 14 per cent.

Digitaria maitlandii Stapf et C. E. Hubbard.—A tufted perennial mostly 1½–2 ft. in height common in western Kenya in the *Combretum-Hyparrhenia* zone. This grass is rather stemmy and of low feeding value.

Digitaria milanjiana (Rendle) Stapf.—A stoloniferous or tufted perennial very common in dry areas. This grass is highly palatable but our analyses show that its protein content is not above average and that it is relatively very poor in phosphorus.

Echinochloa haploclada (Stapf) Stapf.—A tufted perennial 2–5 ft. in height which occurs on stream banks and in swamps from sea-level to about 6,500 ft. altitude. Our analyses show that this grass has a relatively high crude protein content.

Eleusine sp. (Herbarium specimen No. AB 3649).—A strong perennial which resembles *Eleusine indica* (L.) Gaertn. This grass occurs in the northern part of Kenya near the Ethiopian border. It forms very strong tufts and has tough stems and leaves. The crude protein and phosphorus values recorded for this grass are good while the high crude fibre value reflects the toughness of the plant.

Elyonurus argenteus Nees.—A tufted perennial 1–2½ ft. in height which occurs in moderately dry areas. It is a very early grass which provides some grazing at the end of the dry season. The crude protein value recorded for this grass is not particularly striking, the crude fibre value is high and the phosphorus value is relatively low.

Entolasia imbricata Stapf.—A tufted perennial 2–4 ft. in height, found in swamps in the Nyanza Province. This grass is rather stemmy, but fortunately its stems are soft. Our analyses indicate that this grass is rich in protein and that it is not fibrous.

Eragrostis caespitosa Chiov.—A low-growing tufted perennial common in arid and semi-arid areas where it provides useful grazing. Its crude protein content is almost 9 per cent, and its fibre content nearly 38 per cent.

Eragrostis sp. aff. *E. curvula* (Schrad.) Nees (Kitale introduction No. K5264).—A tufted perennial 1½–3 ft. in height which occurs occasionally near Machakos and Nairobi. This grass, although of low palatability, may be useful for reseeding denuded land in moderately dry areas.

Eragrostis paniciformis (A.Br.) Steud.—A tufted perennial common in many parts of Kenya under swampy conditions. This grass is very fibrous.

Eragrostis superba Peyr.—A tufted perennial 1–2½ ft. in height common in arid and semi-arid parts of Kenya. It is often an important component in pastures and it is well liked by cattle. *E. superba* has been used for reseeding denuded land in dry areas and in such areas it has also been successfully tried as a ley grass. Its crude protein content is fairly high, and it contains a respectable amount of phosphorus.

Eulalia geniculata Stapf.—A perennial about 1 ft. in height with ascending stems creeping at the base, which occurs occasionally on stream banks at medium altitudes. This grass, which is under trial at Kitale, is rich in crude protein, but relatively poor in calcium and phosphorus.

Eustachys paspaloides (Vahl) Lanza et Mattei.—A perennial 1–2 ft. in height forming slowly spreading colonies. It occurs in arid and semi-arid areas, often on seasonally waterlogged ground. This grass is leafy and it is well liked by grazing animals. Our analyses show a reasonable level of crude protein phosphorus and calcium.

Helictotrichon elongatum (Hochst. ex A. Rich.) C. E. Hubbard.—A tufted perennial 2–5 ft. in height which occurs at altitudes over 6,500 ft., usually in seasonal swamps. This grass is stemmy but the stems are not hard and so the grass is not particularly fibrous. Its crude protein content is relatively high.

Hyparrhenia filipendula (Hochst. ex Steud.) Stapf.—A tufted perennial 2–5 ft. in height, common under a wide range of conditions from sea-level to about 8,000 ft. altitude. This grass has a rather poor feeding value, as is indicated by its low content of crude protein and phosphorus and its high content of crude fibre.

Hyparrhenia lintonii Stapf.—A perennial forming broad cushions 6 in. to 2 ft. in height. It often occurs on black clay soil that becomes seasonally waterlogged. This grass has very numerous fine stems and a large bulk of leaves. Its crude protein content is satisfactory and its calcium content is relatively high. Although not aromatic, *H. lintonii* has a high content of "ether extractives".

Hyparrhenia rufa (Nees) Stapf.—A tufted perennial 4–8 ft. in height which is widespread in Kenya from the coast to about 7,000 ft. altitude. In the Nyanza Province it is common in seasonal swamps. The crude protein content of this grass is very low, and the phosphorus content is exceedingly low.

Ischaemum brachyatherum Fenzl ex Hack.—A rhizomatous perennial 3–5 ft. in height forming slow spreading colonies in seasonally waterlogged flats of black heavy clays at altitudes from 3,000 to over 6,000 ft. This grass is tough and unpalatable to cattle. Its crude protein content is not very low but its fibre content is high.

Loudetia kagerensis (K. Schum.) C. E. Hubbard ex Hutch.—A tufted perennial 1–3 ft. in height widespread in Kenya. It is particularly common in the *Combretum-Hyparrhenia* zone, especially on poor soil. This grass has very numerous fine and wiry stems and it is of low palatability.

Loudetia simplex (Nees) C. E. Hubbard.—A tufted perennial which resembles *L. kagerensis* in habit but is usually less stemmy. Our sample contained over 10 per cent of crude protein.

Miscanthidium violaceum (K. Schum.) Robyns.—A perennial 6–12 ft. in height with large and hard erect leaves which forms large tussocks in swamps and on swamp-edges. Only the leaves were analysed and these contain a very small amount of crude protein and phosphorus and a very high proportion of crude fibre.

Panicum coloratum L.—A tufted pernnial 18 in. to 3 ft. in height, widespread in Kenya, mostly in open grassland on slightly waterlogged ground where it forms occasionally almost pure stands. This grass is under trial for introduction into cultivation and shows good promise. Our analyses show that *P. coloratum* is rich in crude protein and that it is not unduly fibrous.

Panicum deustum Thunb.—A strong tufted perennial 3–7 ft. in height with thick stems and large leaves. It occurs in bush in arid and semi-arid parts of Kenya. The crude fibre content of this coarse grass is surprisingly low, but its phosphorus content is very low.

Panicum meyerianum Nees.—A tall perennial with ascending stems which occurs on stream banks at altitudes below 5,000 ft., mostly in arid areas. Its feeding value, as judged on chemical analyses, is not high.

Pennisetum catabasis Stapf et C. E. Hubbard.—A perennial 2–4 ft. in height which forms dense tussocks in swamps and on seasonally waterlogged ground. This grass is particularly abundant in the south-eastern part of Nyanza Province. It is usually unpalatable and of low feeding value. Chemical analyses support this viewpoint.

Pennisetum massaicum Stapf.—A perennial 1–2 ft. in height which occurs in arid and semi-arid areas. Our analyses indicate that this grass may be of fair nutritive value.

Pennisetum mezianum Leeke.—A tufted perennial with much branched stems which are usually 1 to 2½ ft. in height. It occurs on seasonally waterlogged black clays where it is often very numerous. This grass is of low palatability, though our analyses show that its feeding value after one year's growth is reasonably satisfactory.

Pennisetum schimperi A. Rich.—A tufted perennial 2–4 ft. in height with numerous hard and wiry stems. This grass covers large areas of the highland-grassland at altitudes over 6,500 ft., and it is unpalatable to grazing animals. Our analyses of its herbage at an early flowering stage show that its crude protein content is not particularly low nor is its fibre content excessively high.

Pennisetum squamulatum Fres.—A robust perennial 3–6 ft. in height. It occurs on rocky ground near Lakes Naivasha and Elmenteita and also occasionally in alluvial valleys in more arid parts of Kenya. This grass is very fibrous and contains an exceedingly small amount of phosphorus.

Pennisetum stramineum Peter.—A rhizomatous perennial 1–3 ft. in height which forms large spreading colonies. It is the main grass in the Laikipia ranching area, where it occurs on black or grey soils; it is also common in other parts of Kenya, particularly towards the Tanganyika boundary. The sample analysed indicates that this grass is of very fair nutritive value.

Pennisetum trisetum Leeke.—A rhizomatous perennial 5–10 ft. in height which occurs on forest edges at altitudes above 7,000 ft. This robust grass is of low palatability.

Setaria atrata Hack. ex Engl.—A perennial forming strong tussocks on seasonally wet ground at altitudes from 6,000 to 9,000 ft. The crude fibre content of this robust grass is surprisingly low.

Setaria holstii Herrmann.—A tufted perennial 2½–6 ft. in height, common in western Kenya mostly on roadsides and on forest edges. Our sample contained 10 per cent of crude protein.

Setaria phleoides Stapf.—A tufted perennial 1½–3 ft. in height common and often abundant on seasonally waterlogged black clays. Its palatability is low and our analyses show that its feeding value at the flowering stage may only be regarded as average.

Sorghastrum rigidifolium (Stapf) L. Chippindall.—A robust perennial 3–6 ft. in height which forms large tussocks in swamps and on seasonally wet ground at altitudes from 4,000 to 7,000 ft. This grass is unpalatable and its chemical composition indicates its very low feeding value.

Sporobolus phyllotrichus Hochst.—A low growing rhizomatous perennial which, under cultivation, can form a dense sward. Its feeding value is fairly high. Our sample of *S. phyllotrichus* contained 13 per cent of crude protein and 0.37 per cent of P.

Sporobolus pyramidalis Beauv.—A tufted perennial 2–3 ft. in height which is widespread in Kenya. It has tough stems and leaves and is of low palatability. The chemical composition of *S. pyramidalis* is relatively poor.

Sporobolus robustus Kunth.—A large tough perennial 4–8 ft. in height which occurs on alkaline ground. It is of low palatability and it is very fibrous.

Trachypogon spicatus (L.f.) Kuntze.—A tufted perennial 2–3 ft. in height which occurs at altitudes from 5,000 to 9,000 ft. and is numerous in some parts of the Uasin Gishu Plateau. The low crude protein content and the high fibre content of *T. spicatus* support the view that this grass is a poor feed.

REFERENCE

[1] Edwards, D. C. and Bogdan, A. V. (1951). *Important Grassland Plants of Kenya*. Sir Isaac Pitman & Sons Ltd., London.

The Chemical Composition of the Grasses of Kenya

(*Per cent of dry matter*)

Botanical Name	Date harvested	Ash	Crude Protein	Ether Extract	Crude Fibre	Carbo-hydrate	Ca	P
Agrostis schimperiana	7–5–57	10·66	17·93	2·12	28·16	41·13	0·34	0·22
Alloteropsis semialata	24–4–57	9·02	15·64	1·06	14·74	59·54	0·14	0·30
Andropogon chrysostachyus	26–5–56	7·69	6·66	2·94	41·37	41·34	0·24	0·19
Andropogon distachyus	1–6–57	7·40	5·20	2·15	43·34	42·02	0·25	0·14
Andropogon schinzii	1–6–57	8·86	10·30	2·22	37·92	40·70	0·30	0·15
Anthephora hochstetteri	7–5–57	9·70	12·85	2·46	32·30	42·69	0·41	0·16
Aristida adoensis	9–5–56	9·70	11·73	2·31	32·51	43·75	0·33	0·18
Arundinella nepalensis	7–5–57	9·86	9·92	1·40	37·27	41·55	0·37	0·20
Bothriochloa radicans	26–5–56	8·60	10·25	3·69	28·75	48·71	0·45	0·27
Brachiaria decumbens	9–5–56	9·91	11·18	2·85	27·98	48·08	0·33	0·18
Brachiaria dictyoneura	1–6–57	9·83	5·10	1·60	37·39	46·08	0·25	0·19
Brachiaria platynota	1–6–57	9·68	6·41	1·61	35·30	47·00	0·34	0·22
Brachiaria serrata	17–7–56	11·50	8·43	1·97	33·93	44·17	0·14	0·05
Cenchrus setigerus	7–5–57	11·90	18·65	1·89	28·30	39·26	0·19	0·23
Cymbopogon afronardus	1–6–57	8·38	8·22	3·36	35·13	44·91	0·28	0·13
Cymbopogon giganteus	17–7–56	6·49	4·96	4·14	33·25	51·16	0·29	0·08
Cymbopogon pospischilii	26–5–56	8·01	7·14	4·03	29·73	51·09	0·22	0·19
Cypholepsis yemenica	7–5–57	7·82	15·53	1·79	37·93	36·93	0·33	0·16
Digitaria diagonalis	1–6–57	5·83	6·27	1·94	38·88	47·08	0·25	0·13
Digitaria gazensis	26–5–56	8·10	13·74	3·73	28·17	46·26	0·43	0·20
Digitaria maitlandii	1–6–57	8·30	6·37	1·53	38·49	45·31	0·23	0·13
Digitaria milanjiana	1–6–57	9·67	8·13	2·26	36·80	43·14	0·32	0·14
Echinochloa haploclada	26–5–56	11·26	13·73	2·98	30·69	41·34	0·37	0·21
Eleusine sp.	26–5–56	8·55	11·92	2·69	34·14	42·70	0·47	0·24
Elyonorus argenteus	1–6–57	7·51	8·02	1·87	37·82	44·78	0·26	0·14
Entolasia imbricata	24–4–57	8·46	19·47	1·12	14·76	56·19	0·25	0·15
Eragrostis caespitosa	1–6–57	8·09	8·72	1·79	37·52	43·88	0·49	0·17
Eragrostis sp. near *E. curvula*	7–5–57	7·38	8·01	2·00	34·91	47·70	0·46	0·19
Eragrostis paniciformis	9–5–56	4·58	8·61	2·96	36·64	47·21	0·33	0·12

THE CHEMICAL COMPOSITION OF THE GRASSES OF KENYA—(*Contd.*)

BOTANICAL NAME	Date harvested	Ash	Crude Protein	Ether Extract	Crude Fibre	Carbo-hydrate	Ca	P
Eragrostis superba	7–5–57	6·58	11·32	1·93	32·28	47·89	0·51	0·24
Eulalia geniculata	7–5–57	7·90	18·51	2·19	26·76	44·64	0·16	0·17
Eustachys paspaloides	1–6–57	9·95	9·74	2·58	33·76	43·97	0·49	0·24
Helictotrichon elongatum	7–5–57	8·14	12·52	2·39	32·31	44·64	0·37	0·17
Hyparrhenia filipendula	1–6–57	5·83	6·62	1·84	36·34	49·37	0·30	0·10
Hyparrhenia lintonii	26–5–57	8·56	11·45	5·00	31·77	43·22	0·49	0·26
Hyparrhenia rufa	17–7–56	7·19	5·20	1·31	38·34	47·96	0·22	0·06
Ischaemum brachyatherum	7–5–57	9·03	9·65	2·13	36·34	42·85	0·40	0·21
Loudetia kagerensis	26–5–56	7·99	8·54	1·66	34·98	46·92	0·18	0·21
Loudetia simplex	1–6–57	5·56	10·42	1·80	37·98	44·24	0·39	0·16
Miscanthidium violaceum	17–7–56	3·97	5·47	1·71	40·81	48·04	0·10	0·09
Panicum coloratum	7–5–57	11·05	18·93	2·63	28·61	38·78	0·23	0·18
Panicum deustum	17–7–56	8·77	9·37	2·39	28·95	50·52	0·37	0·11
Panicum meyerianum	1–6–57	9·08	9·69	2·28	34·70	44·25	0·36	0·17
Pennisetum catabasis	1–6–57	5·76	6·88	2·03	40·20	45·13	0·19	0·09
Pennisetum massaicum	1–6–57	11·03	9·78	2·00	35·46	41·73	0·30	0·24
Pennisetum mezianum	9–5–56	10·88	10·82	2·65	32·07	43·58	0·55	0·28
Pennisetum schimperi	9–5–57	7·26	8·98	2·94	35·62	45·20	0·36	0·14
Pennisetum squamulatum	17–7–56	8·57	7·03	2·50	39·27	42·63	0·09	0·07
Pennisetum stramineum	26–5–56	10·56	11·92	3·20	35·79	38·53	0·37	0·27
Pennisetum trisetum	17–7–56	7·56	8·66	2·35	31·56	49·87	0·22	0·07
Setaria atrata	9–5–56	10·03	9·54	2·53	29·88	48·02	0·33	0·21
Setaria holstii	26–5–56	12·23	10·06	2·15	33·93	41·63	0·30	0·32
Setaria phleoides	1–6–57	8·31	9·14	1·60	39·08	41·87	0·29	0·11
Sorghastrum rigidifolium	1–6–57	6·89	6·76	1·35	43·41	41·59	0·23	0·10
Sporobolus phyllotrichus	7–5–57	9·93	13·14	2·10	30·92	43·91	0·33	0·37
Sporobolus pyramidalis	26–5–56	6·20	7·66	1·75	35·92	46·41	0·21	0·18
Sporobolus robustus	17–7–56	7·29	11·18	2·39	38·45	40·69	0·25	0·11
Trachypogon spicatus	17–7–56	9·60	5·70	1·82	40·16	42·72	0·15	0·10

AGRICULTURAL MACHINERY IN EAST AFRICA

(Points from a Conference held at E.A.A.F.R.O., Muguga, 14th February, 1958, with Dr. E. W. Russell as Chairman)

This conference brought out the importance of co-operation in machinery development, not only between territories but also between field officers and specialist officers within a territory. The field officer can greatly assist the agricultural engineer by pin-pointing the field problems which could be solved by mechanization. For example, in Uganda the yield of cotton, and possibly also its acreage, could be increased in some areas if the millet crop could be harvested more quickly or with less hand labour. For cotton ought to be planted at the time of the millet harvest, and late planting reduces its yield very considerably. Hence this peak demand for labour delays planting and reduces both the yield and the acreage sown. A simple hand-operated header is being developed to speed-up harvesting, and it is hoped that a simple thresher for this headed millet will be devised before long. It would be a great advantage to have in each territory one officer who is aware of the machinery developments, and who could co-ordinate the work of the agricultural engineer and the farmer, as one of the greatest difficulties the engineers are working under is that of obtaining information on the agricultural problems that are in most need of better machinery. The need for better publicity about new machines was also stressed, one example of this being the lack of knowledge of the existence of a rotavator which has been developed for use in coffee plantations.

TESTING AND DEVELOPMENT OF AGRICULTURAL MACHINERY IN EAST AFRICA

The Tanganyika Agricultural Machinery Testing Unit is primarily concerned with peasant farming and the testing of oxen-drawn and hand implements, but trials are being made on the mechanical transportation of cotton in bulk from the store to the ginnery without the inefficient process of bagging and unbagging.

The Special Development Section of the Uganda Department of Agriculture is concerned with the mechanization of African farming, and it has a Contract Hire Service which operates between 40 and 60 tractors, the scheme being subsidized by Government to some extent. Field officers of the scheme advise farmers on the choice of new tractors, and they often provide mechanics to help with maintenance. The Section has stocked certain lines of agricultural machinery for sale until the trade agents considered them profitable. All Government tractors and equipment have been brought through the local agents, who can thus be persuaded to keep good stocks of spares.

A training school for tractor drivers is also run by this Section, where the maintenance of equipment is also taught. These courses have shown how important it is to design tractors and implements so that their maintenance is as easy as possible.

This Section is trying to make minor modifications to tractors to ease the problem of maintenance: for example they are making minor modifications to radiators so that grass cannot block the airflow, and they are raising the air inlet and fitting a visual pre-cleaner to it so that the driver can see the dust accumulating. They are also fitting extra fuel filters.

The East African Tractor and Implement Testing Unit is financed by the Colonial Development and Welfare Fund, is technically controlled by the National Institute of Agricultural Engineering, and is administratively controlled by the Director of Agriculture, Kenya. In its original conception, the primary function of the Unit was to test tractors, but it was agreed early on that implement testing should receive about as much attention as tractor testing. The first result of importance to come out of the tractor-testing work was the very great difficulties involved in the correct adjustments of fuel and air intakes at high altitudes for efficient combustion of fuel. The implement-testing work has been with bush-breakers and rotary-mowers, and a number of improvements to these machines have been suggested.

MECHANIZATION ON THE SMALL AFRICAN FARM

At first sight the low initial cost and easy manoeuvreability of small market-garden type tractors would appear to make them ideal for African agriculture. However, attempts to introduce these tractors have failed for a variety of reasons, principally because they were designed for friable market-garden soils and so are underpowered for hard-baked African soils. Trials are to be carried out in Uganda with Rollo Croftmaster tractors which have been used successfully in the Highlands of Scotland, but it may be that there is still not enough knowledge of mechanical equipment amongst African farmers, and repair bills, not initial outlay, may be the limiting factor. Loss of power at high altitudes is very important in a light tractor which is already underpowered, and this must also be taken into account in the search for a small tractor for African use.

SOME PROBLEMS OF MECHANIZATION FOR SPECIALIST CROPS

Pyrethrum

An important cultivation problem in pyrethrum is the eradication of stoloniferous grasses after the ley and before planting. For example, Kikuyu grass (*Pennisetum clandestinum*) can be eradicated by repeated ploughing and harrowing, but any soil structure which has been built up under the ley is destroyed by the intensive cultivation. Herbicides may provide the answer to this problem, but special low-speed rotavators, of the type developed for cultivation in a coffee plantation, which leave the soil surface in a good tilth, may also play a part, particularly in inter-row cultivation for weed control. Several mechanical transplanters have been tried, but none was completely satisfactory, and there is also need for ridging equipment with an attachment for placing fertilizers below the ridge.

Existing designs of pyrethrum driers are suitable for large-scale growers, and a new drier suitable for the small grower has recently been designed and built, and it promises to be very efficient. Many of the driers now in use are oil-fired, and there is some uncertainty about the effect of fumes from oil burners on the quality of the pyrethrum. Electric heating was suggested to solve this difficulty, but it appears that the very high load required would render this uneconomic.

Sisal

Sisal growers have been consistently mechanically minded and have welcomed any suggestions that would reduce hand labour. In clearing old fields a Marsden bush breaker drawn by a D8 tractor is adequate, but there is a delay of a year before the old boles have rotted down and the field can be ploughed, and it might be an advantage to find a method of avoiding this delay. The cost of weed control in bulbil nurseries can be greatly reduced by means of herbicides, but some hand weeding is still necessary, and it was suggested that a power frame tractor would be worthy of trial, possibly a David Brown 2B with special adjustments to suit bulbil spacing. But the power frame tractor needs a high degree of skill if it is to be used for really accurate hoeing, and it is possible that a steerage hoe behind an ordinary light tractor might be more suitable for this work.

Rotary mowers, such as the Gyromor and the Henderson slasher, have proved admirable for field upkeep, as this type of weed control reduces transpiration by the weeds without disturbing the soil or cutting the surface roots of the sisal plants. In field operations it would be of great assistance if a modified fertilizer distributor could be devised which would place fertilizers close to the plant, since African labourers are not reliable for this work. The mechanical transport of leaves from the cut sisal plant to the factory needs considerable improvement, and some kind of trailer drawn by a four-wheel tractor might be more efficient than the present methods.

In general, there is considerable scope for improving mechanization on the sisal plantation, but it will probably be necessary to marry the agricultural method to the machine, and spacing and plant populations may have to be altered.

LOCUST CONTROL BY AIRCRAFT IN CENTRAL AND EAST AFRICA

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Locusts are economically important because they cause extensive damage to crops during sporadic but long-lasting plagues. There are five important species of locusts in Africa, and the areas invaded by them collectively extend over virtually the whole of the continent [1]. The permanent breeding grounds or outbreak areas of all but one of these species are now known, and the current aim is to prevent plagues by control operations in these places. The exception is the Desert Locust (*Schistocerca gregaria* Forskal) which seems to have a number of potential outbreak areas scattered over too extensive an area for suppression measures to be sufficiently effective. The outbreak areas of two of the other species (*Nomadacris* and *Locusta*) are very small in relation to the invasion areas so that the difficulties of preventing locust plagues are far less than those of combating them. There are, however, problems of finding the best methods of locust destruction. Swarms of winged adults are mobile and large, and when there are swarms, they are often numerous and distributed widely. Swarms are too active to be attacked from the ground in the day-time and they may settle at night in inaccessible places. Control methods are therefore required which operate speedily and independently of difficulties of terrain and swarm mobility. The wingless hoppers (nymphs) occur in bands which are easier to attack, but they are difficult to find and destroy completely enough to prevent swarms. A great deal of effort from all over the world by differently specialized scientists and technicians has gone into the development of control methods. Much attention has been given to the aeroplane for anti-locust operations because it can operate quickly and freely over vast stretches of difficult country where ground methods are impracticable.

The first attempt to control locusts from the air took place as long ago as 1923 in the Philippines [2]. This was followed by operations in Russia [3, 4], United States of America [5, 6, 7, 8], South Africa [9] and in Rhodesia [10]. Arsenical insecticides were mostly used for dusting and baiting locusts by aircraft, and although extensive infestations were sometimes attacked, especially in the United States of America, there was little effective progress in aerial methods up to the beginning of the last war. Then, during the war, the urgency of fighting a new Desert Locust plague led the Anti-Locust Research Centre, London, to initiate a series of trials of aircraft in Africa [1]. The practical results of the work were not immediately satisfactory but lessons learned cleared the way for the further researches and successful developments made during the next decade.

The first operations in this series were carried out in Kenya, in 1944, under Dr. J. S. Kennedy [11]. His experience indicated a need for laboratory studies, and Dr. Kennedy returned to the Chemical Defence Experimental Establishment, Porton, to investigate the physics and chemistry of attacking locusts by insecticides applied from aircraft [12]. A second group of trials took place also in Kenya in 1945 under Dr. D. L. Gunn [13]. Twin-engined medium to heavy aircraft were used mainly for both series of operations, and the usual method was to attack settled swarms that were located and marked by ground parties. Dusting with 14 per cent dinitro-*ortho*-cresol (D.N.C.) was unreliable and too slow a method, for only trivial areas could be attacked before the swarms took to flight [11]. It was evident that further knowledge of locust swarm behaviour was required, and within a few months substantial results had been obtained [14]. Two techniques of spraying devised by the Porton staff were tried, one against settled swarms and one against swarms in flight [13]. The insecticide—2½ per cent D.N.C. in oil solution—was effective, but an expensive ground co-operation team was required and the value of the high speed of aircraft was largely lost because of their dependence on much slower ground parties. Further developments in attacking Desert Locusts have been outlined by Dr. R. C. Rainey [15, 16, 17] and have involved, for example, not only a deeper analysis of the physics and physiology of insecticide attack [18, 19, 20, 21, 22] but also a more detailed understanding of locust behaviour, especially in relation to synoptic meteorology [23, 24, 25].

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In 1947 there was an alarming upsurge of the Red Locust (*Nomadacris septemfasciata* Serville) in its outbreak areas, notably in the Rukwa Valley, Tanganyika Territory. It was feared that an outbreak might lead to a plague, so aerial spraying measures were hurriedly organized under Dr. Gunn and Mr. H. A. F. Lea [26]. There was by then available a specially developed oil solution of 20 per cent D.N.C. whose properties had been worked out at Porton, and this was sprayed on settled swarms using twin-engined Avro Anson aircraft. The Porton method was used again for spraying and results of using the new poison formulation sprayed at a rate of 1 gal./acre were remarkable—there were sometimes virtually complete locust mortalities using dosages as little as ½ gal./acre of the D.N.C. liquid, in spray having a mass median diameter (m.m.d.) of 0.43 mm. (430 microns) [27]. Benzene hexachloride (B.H.C.) oil solution containing 2 per cent gamma isomer was also sprayed at dosages varying from 3.4 to 5.2 gal./acre, but results were unsatisfactory. The locusts were too active to spray after about 8 a.m., so control had to be carried out speedily, and an average extent of 45 acres of locusts was attacked per spray flying-hour. The Red Locust outbreak areas are flat, treeless flood-plain grasslands, which were then extensively dry, so that, unlike the Kenya operations, the circumstances were very favourable for ground parties to operate freely and quickly for reconnaissance, swarm delimitation and demarcation; locust mortalities were also easier to assess. Nevertheless the technique was still limited by the necessity for ground marking, so that although the aerial spraying campaign was highly successful it was costly; it was clear also that methods of attacking flying swarms needed to be improved in order to use aircraft more extensively and to reduce their costs. It was then suggested that since a ground party was necessary, that party might itself kill the locusts more cheaply and just as well as by aircraft by using instead, specialized ground machinery for attacking the Red Locust with 20 per cent D.N.C. by low-volume drift spraying [26, 28]. The proposal was feasible because the known outbreak areas of the Red Locust are fairly closely grouped and are only about 2,000 square miles in extent (cf. the Desert Locust invasion area extending over 3,000,000 square miles) [29].

A prototype airflow ground machine for attacking Red Locusts by drift-spraying was then designed by Dr. H. G. H. Kearns, at Long Ashton Research Station, University of Bristol [30]. This and lighter, but similarly designed commercial machines which were later obtained, were able to spray about 30 acres of locusts an hour, though they could not be used on some of the terrain [31, 32]. They were thus not so fast in action as the Anson aircraft, but they were believed to be fast enough provided they were not faced with a large peak of swarms to control. These machines had to be used at night, for the locusts were too active to be sprayed in the day-time, and this had several disadvantages. On good terrain, however, one of these machines could attack a greater extent of locusts during one night than an aircraft restricted to air-to-ground spraying could deal with in one morning. The airflow-type machine also cost less to use than the Anson aircraft.

The effectiveness of aircraft in emergencies against upsurges of locusts and grasshoppers had by that time been amply confirmed by other post-war campaigns in the United States of America, Canada [4], Australia [33], and in South America [34]. The success of most of these operations seemed to be due to favourable terrain allowing ground parties to operate. No method had been developed for attacking swarms in flight, though aeroplanes were used successfully for scouting for swarms of *Schistocerca paranensis* Burm. in Uruguay in 1947 [34]. The aircraft used were mostly medium to heavy converted bombers or transport planes. They carried big poison loads so that although they required special airfields with long runways, and often operated against swarms far from their bases, they were able to spray a considerable extent of swarm per sortie, with reasonable spraying costs and sufficiently speedy control. These larger aircraft were, however, too costly for preventive control organizations, though their high cost might willingly be borne during a plague. It seemed clear, therefore, that where locusts could permanently be kept in check in their breeding areas, ground methods would be cheaper in the long run than the intermittent great expense of large aircraft. The operational superiority aircraft may have over ground methods or vice versa, cannot be measured by costs alone, however, but the total effectiveness of each has to be taken into account. Thus, Desert Locust swarms are generally too widely scattered over often impossible terrain for anything but aircraft to be used.

The increasingly successful use of the light aircraft for various kinds of large-scale crop protection was then leading to its special development for spraying, dusting, fogging and baiting. Commercial operators of light aircraft, especially in the United States of America, competed successfully and ousted many ground methods of pest control because they could do a job faster, at less cost, and more conveniently. The small aircraft were found to be sufficiently fast for extensive control to be completed within the time limits set by the pest, and so they were often more effective than the slower ground techniques. Their ability to operate from short, improvised runways near to places requiring treatment aided speed and efficiency, and so did their manoeuvrability, because little time is wasted in turns between runs. They were carrying useful loads of 500 lb. of insecticide or more, depending on the type of aircraft. The light aircraft began to be employed for grasshopper control in the United States of America and Canada [4], along with the then new organic insecticides such as chlordane, toxaphene, aldin and dieldrin.

Early in 1951 the United States of America provided emergency aid for locust control in Iran. Eight small Piper aircraft were used for spraying aldrin on settled locusts, and it was reported that the group attacked 53,000 acres of swarms in 661 flying-hours or an average of 80 acres of locusts per flying-hour [35]. The little machines were therefore very fast and certainly faster than the Ansons used against Red Locusts in 1947. It seemed, however, that though the lightest types were faster than medium-sized aircraft they could not be used so widely, quickly, or cheaply enough to substitute ground methods because of their dependence on ground support. This was confirmed by operations using Piper Cubs in India, in 1951, for neither hopper bands nor swarms of Desert Locusts settled on desert could be located from the air for spraying [36]. Control then carried out by spraying aldrin, therefore, required an extensive ground organization. Comparisons of costs and speed between these aerial and ground methods of killing hoppers showed, in fact, that the ground organization needed for aerial spraying could carry out control by itself using machines ten times more cheaply than aircraft [36]. In Madagascar also, during 1949 and 1950, light Piper Cub aircraft and helicopters were used for dusting swarms of Migratory Locusts (*Locusta migratoria capito*) with gamma B.H.C. dust [37]. Aerial reconnaissance for swarms proved impracticable, and dusting swarms in flight by helicopters seemed to be ineffective, possibly because the dosages of gamma B.H.C. used against adult locusts were too small, judging by dosages required for other species. Even the helicopters had to be aided by ground parties for attacking bands of hoppers, which made them less economical than ground dusters. The light aircraft did not look a promising weapon in spite of its mobility and manoeuvrability.

It was not long afterwards, however, that very successful results were obtained with light aircraft against locusts elsewhere. In South Africa, in 1953, a Piper Super Cub "135" was used against an upsurge of the Brown Locust (*Locustana pardalina* Walker) in its breeding areas in the Karroo Desert. Aerial dusting was unsatisfactory, but virtually complete kills were obtained when the machine was converted for spraying settled swarms with a dosage of 1 gal./acre of 4 per cent gamma B.H.C. in oil [38]. The aircraft was equipped with a four-wheeled undercarriage which allowed it to operate from unprepared obstacle-free flat ground near swarms. The control done was fast, and my estimates of some operations showed that the aircraft sprayed about 65 acres an operational hour, and cost little more than the drift-spraying ground units then being used for Red Locust control. Moreover, the machine was successfully used for finding and spraying swarms in flight [38] so that extensive infestations were sprayed in a day. The aircraft also attacked a heavy hopper infestation successfully, but with ground aid [38]. The aircraft was equipped with boom-and-nozzles spray gear and the method of attacking settled swarms was by drift-spraying the poison on swaths only 20 yards wide. The flying height was 10 to 15 feet and the flying speed was 70 to 80 m.p.h., the spray emission rate for an area-dosage of 1 gal./acre of liquid was about 10 g.p.m. This technique was simpler, and did not need such a large ground organization as the Porton method, in which swaths of 50 to 200 yards or more were sprayed from flying heights of up to 200 feet using emission rates up to three gallons per second; wind measurements were also needed for the Porton method so that heights could be adjusted to apply a consistent area-dosage and to make reasonable allowance for drift at the edges of the target. Though no details of performance and costs of using this little aircraft for Brown Locust control have been circulated, it has been recorded that it led to saving in time and insecticide, and presumably money, compared with ground machinery [38].

Successful developments were also being made by Dr. R. C. Rainey and Mr. H. J. Sayer, of the Desert Locust Survey, who were using light aircraft for attacking flying swarms of the Desert Locust in East Africa [15]. They used single-engined Auster J1/B and Auster J5/G spraying aircraft also equipped with boom-and-nozzles spray gear. By this time Mr. K. F. Sawyer, at Porton, had worked out curtain-spraying in greater detail [18], but observations on speeds and behaviour of flying swarms indicated that both the "aerial curtain" and "static curtain" spraying methods [13] would be inapplicable. Rainey and Sayer found, however, that flying swarms, especially small ones, could be attacked effectively by flying through them while spraying. The important factor seemed to be drop size; finer sprays of D.N.C. and gamma B.H.C. oil concentrates were tried and a drop spectrum with a mass median diameter of 140-150 microns gave better results.

These developments in South and East Africa were timely for Red Locust control, for in 1954 there was an upsurge in Rukwa Valley which overwhelmed ground control. The situation was saved by two Auster J5/G spraying aircraft that had been lent immediately by Desert Locust Control. These aircraft first destroyed a swarm which had escaped from one of the outbreak areas; it was attacked in flight without difficulty. The equipment was clearly suited to the job, the airmen knew what to do, and the flat compact swarm was rather an easier target than the huge cumuliform masses they were accustomed to spraying. Aerial spraying was then continued successfully against both settled and flying locusts in the North Rukwa outbreak areas. Later, during the hotter months, the locust situation flared up again and this time a swarm escaped for good. Single-engined spraying aircraft were chartered again and both Auster J5/G and Piper PA-18A "135" types were used. The upsurge provided opportunity for profitable operational research [32] and the striking power of these little aircraft was worked out in detail during these operations; nearly the whole of control of adult locusts was thereafter done by aerial spraying, ground operations having been stopped so as to free staff for scouting. There were no more swarm escapes.

It was clear that scouting methods then used had been inadequate and the ground machines could not operate extensively or quickly enough to prevent an outbreak. They were ineffective for other reasons such as the use of insufficient dosages, unsatisfactory insecticide emulsions, and demarcation faults, to mention a few. There was also an unusual lack of winds steady enough for drift-spraying so that the powerful airflow-type machines could not be used; it was learnt later that dry-season winds failed also in 1945, which was also an arid year in Rukwa [39], and a year when extensive swarming resulted in emigration of 50-100 swarms [40]. Clearly, drift-sprayers were impracticable if aridity is associated not only with upsurges of the Red Locust, but also with an absence of winds suitable for spraying wide swaths. Other ground machines which had to be used were capable of spraying only three to six acres of locusts an operational hour so that they were far too slow for controlling infestations amounting to thousands of acres in extent. The speed of attack by light aircraft averaged 85 acres in a spray flying-hour, and 66 acres an operational hour, which includes time on the ground between sorties. The aircraft were therefore 10 to 20 times faster than the ground machines and were, indeed, the fastest and most effective weapons ever used for Red Locust control. Moreover, the cost of controlling an acre of locusts by chartered aircraft was nearly 20 per cent less than that of using ground machines. The aircraft were used sparingly because of insecticide shortage, and it seemed that if they could be utilized fully they might cost about 50 per cent less than ground units. Obviously, the conclusions reached from the use of larger aircraft against Red Locusts in 1947 had been much affected by type of aircraft and method of spraying used.

The use of the light aircraft increased not only effectiveness but also security, because time after time successful air attacks were made on both settled and flying swarms that were unknown to ground parties. The risks of swarms escaping unnoticed was therefore greatly reduced. There was no situation at all which these aircraft failed to control. The aircraft operated from airstrips made by little more than mowing the grass on smooth parts of the plains only a few miles from infestations, so that extensive areas were sprayed without waste of flying time; and the aircraft were sufficiently mobile to cope with situations that suddenly flared up. The method used for assisted air-to-ground spraying was the same as had been used in South Africa except the insecticide was 20 per cent D.N.C. against the Red Locusts. The Porton method of spraying would actually have been inapplicable because of unsteady winds early in the morning; the risk of uneven coverage was therefore less with swaths only 30 yards wide. Swarms in flight on the plains were easy to spray because they were stratiform and flew little more than 25 feet above the ground in the plains. The aircraft flew a few feet above the swarm and perpendicularly to its heading, for spraying with regularly-spaced runs. The smallness of the swarms aided this sort of attack, and virtually complete swarm kills were obtained with dosages as little as 0.2 gal. of 20 per cent D.N.C. per acre of horizontal swarm. Flight-timing measurements of swarms were used to estimate poison requirement and to indicate the manner in which swarms should be sprayed. The technique is not without imperfections; for instance, it is difficult to judge sometimes when a swarm has been sprayed adequately, and in case of doubt some wastage in poison has to be tolerated, for complete swarm destruction is of the first importance. A very rapid-acting contact insecticide has to be used so that spraying is not needlessly repeated because of apparent survival.

Outbreak suppression requires a state of permanent vigilance and readiness for control, because upsurges develop rapidly and with little warning, especially when populations of hoppers, which cannot be estimated accurately, are moulting finally to become adult fliers. This is a critical time in the Red Locust outbreak areas, because then most intensive control is usually required, and because of flooding it is difficult to move about on the ground. It was clear that ground methods were inadequate to achieve successful preventive control however much men, machines and materials might be increased in numbers for them. Aircraft were faster, cheaper and more widely applicable. Moreover, a hypothetical estimate of the maximum aircraft requirement to control a simultaneous upsurge in all the outbreak areas on the scale that occurred in North Rukwa suggested that four aircraft would do, and that two would be able to deal with average control loads. The decision was then made to replace ground methods of control by two aircraft for it was clear that they would be less costly to buy and maintain, and they were considerably more effective. This led to the construction of all-weather airfields at strategic points at the edges of the outbreak areas.

This step was taken just in time for in 1955 there was a tremendous upsurge of locusts in Rukwa. It was the largest which has ever been recorded in any detail, and virtually all the control done during the year was by chartered Piper PA-18A aircraft; not a single swarm escaped. The magnitude of this achievement is described more clearly perhaps, by the fact that about 1,500,000,000 locusts weighing about 3,000 tons were destroyed in North Rukwa only (this area is about 300 square miles in extent). Nearly 50,000 gallons (about 250 tons) of insecticide were used altogether for spraying roughly 50,000 acres of locusts. In North Rukwa 10,000 gallons of poison were sprayed on flying swarms and destroyed about 530,000,000 locusts. It was estimated from flight-timing measurements of swarms that an average dosage of 0.7 gallons of 20 per cent D.N.C. was applied per acre of horizontal swarm; oil-based sprays having a mass median diameter of 115 microns were found to be very satisfactory for spraying flying locusts [41]. The numbers of locusts destroyed per gallon of insecticide is, of course, small, compared with what can be achieved against Desert Locusts in a plague [15], but the required results are obtained. In order to deal with the upsurge single aircraft sometimes sprayed as much as 6,700 acres of swarms in a month. The effort was intensive but the strain was not undue. Aerial searching contributed greatly to the success of the campaign, and aerial control flexibility resulted in no infestation being unattackable. Such was the independence of aircraft of ground support that only 48 per cent of the spraying sorties were given detailed ground assistance, the other unaided operations taking place against swarms in flight and in positions which could not be reached from the ground. The aircraft used during the year cost £13,000 so that the cost of aircraft per acre sprayed was 5s. 2½d., or roughly 16s. including the cost of insecticide; this was little more than half the cost of using ground machines. It was evident that there would be greater savings if the Service owned its aircraft, especially to avoid delays such as occurred in bringing chartered planes from afar.

It cannot be said how many swarms might have left the outbreak areas if there had been no control at all—perhaps 300, perhaps more, certainly enough to start a plague if conditions had been favourable in the invasion area, for such evidence as there is shows that the last Red Locust plague which lasted from 1929 to 1944 started from only a few swarms [29, 42]. It is equally certain that had there been such an upsurge, and had ground methods been relied on, there would have been a large-scale outbreak. The little aircraft had therefore achieved a resounding success.

During the last three years aircraft have been used in routine successfully and the Service now owns two Piper PA-18A "150" aircraft. Their high striking power has facilitated a new policy of letting locust concentration into swarms proceed a long way, destroying them only when they become dangerously migrant; this means that the Service is spared the cost of attacking larger areas of lower density infestations as it did previously in order to avoid peak loads that could not be controlled. The use of aircraft has led to the partial abandonment of the static control system which before had to be maintained in places scattered over the outbreak areas. This has resulted in other savings in cost of manpower and machinery, and in administration. When there is little or no control to do the aircraft are usefully employed for reconnaissance and communications so that their costs are not wasted in favourable times. The full economy of aircraft has not yet been realized, however, because staff and organization have to be maintained for controlling hoppers by ground methods. These methods are known to be inadequate but there is as yet no detailed evidence to show that aircraft have such a striking power as to make hopper control unnecessary. Consequently, further improvements depend on having successful hopper control by aircraft.

Investigations on this were begun in 1956, but little progress has been made because hoppers have been too sparse for realistic operations. It is known now that although bands of Red Locust hoppers as little as 35 square yards in extent can be seen sometimes from the air, at other times much larger bands are invisible, so that direct attack on bands by aerial spraying seems to be too slow and unreliable; more investigations are required. It seems from tests done so far, however, that lattice-spraying with dieldrin applied by aircraft, which does not depend for effectiveness on placement of insecticide on bands, may be an economical method of killing hoppers by residual stomach poisoning [43]. A great deal of further work is needed in order to develop and evaluate methods, and to measure their effects on organization; refinements are also required in aerial techniques for adult locust control, and some newer types of helicopters are thought to be worthy of trial for locust reconnaissance [32].

Preventive control of the Red Locust costs about £200,000 a year [44]. If it works—and so far it seems to have done so—it is economical, for it prevents long-lasting plagues which cause inestimable crop damage and economic disruption [1, 45]. The requirement for success is, however, complete effectiveness—the light aircraft seems to be an economical weapon capable of assuring this, as long as the scale and situation for control is always known well enough so that there are sufficient aircraft in the right places. There have been developments in methods of forecasting [46], and enumeration of populations for forecasting [47], and in non-chemical control [44], but they remain to be proven. This combination though perhaps not yet tried for long enough, seems already to provide considerable security in keeping at bay a scourge in Africa.

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THE DIGESTIBLE PROTEIN OF RUMINANT FEEDS BY CALCULATION

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The nutritive values of animal feeds are normally obtained by digestibility trials with cattle or sheep, in which the food consumed by the animal is weighed and analysed, and all the faeces are collected daily, weighed, and analysed. From these figures the percentage of digestible protein in the feed, and its total digestible nutrients or its starch equivalent, are calculated, and these values are used in computing rations in farm practice. These digestibility trials involve a pre-period and an experimental period on the selected diet, some 24 days in all, from three to six animals are used for each feed in order to allow for individual variations, and a very large number of analyses is required. Thus it is unlikely that more than two samples could be tested per month, with normal facilities, and the large number of feeding values which have been published in America and Britain represent many years of work in a number of laboratories.

In the tropics and sub-tropics comparatively few data are available on the nutritive values of locally grown feeds, and farmers who wish to apply scientific rationing have been obliged to use data which may not be correct for the concentrates which they purchase, or for feeds grown on their farms. Further, the reliability of the feeding value of a sample as determined by a digestibility trial has been questioned by Schneider and Lucas (1950) who have analysed statistically the errors involved in this technique for evaluating feeds. They state "It is apparent, then, that accurate average digestibility data cannot be obtained by any one worker, or by a few workers each doing a large number of trials on a single feed or feed sample . . . to obtain accurate average data will require many workers, each investigating several samples of a feed. . . . It seems evident that the most efficient use of digestibility facilities would be obtained only by co-ordinated and co-operative studies".

In spite of this severe criticism, the scientific rationing of animals for growth and production works quite well in practice, but it is doubtful if a farmer in East Africa should base his rationing on data in the American textbook "Feeds and Feeding" by Morrison (1947) or on the British publication "Rations for Livestock" by Woodman (1954). Even so, rationing for milk production works reasonably well in East Africa, in spite of the great lack of feeding values for the local grasses at different stages of growth and for local hays, silages and concentrates. The explanation may be that calculated requirements of digestible nutrients, particularly that for protein, have such a large margin of safety that variations in the feeding value of a particular feed are of minor importance. It is noticeable that requirements of digestible protein by dairy cows for milk production given in Morrison's feeding standards for the U.S.A. are lower than those for Britain given by Woodman: in short, the "scientific" rationing of cattle and sheep for maintenance, growth, and production is still an art which is merely guided by science. It may be that the secret of success is to feed more protein than is actually required by the animal, but in East Africa protein is an expensive feed component during most of the year, and it is of economic importance that more information should be available on the nutritive values of local feeds in order that the safety margin for protein can be reduced.

Two papers have recently been published (Glover *et al.* 1957: French *et al.* 1957) in which the results of many hundreds of direct digestibility trials with cattle, sheep and goats have been analysed statistically, and it has been found that, for these ruminants, there is a relationship between the crude protein content of a feed and the digestibility of the protein. The feeds included grasses, hays, silages and concentrates, but no statistical difference could be detected due to the kind of feed, whether fed singly or in a mixed ration. Further, no difference could be detected between cattle, sheep, and goats whatever the breed or type, and results from Europe, the Americas, Africa, India, Australia and New Zealand all conformed to the common relationship. This relationship is in the form of a curve, which is shown in Fig. 1, and the equation in its simplest form is:—

$$\% \text{ digestibility of crude protein} = 70 \log \% \text{ crude protein of feed} - 15.$$

The protein digestibility obtained by this calculation is the "average apparent digestibility" of the protein, and the value obtained for a single feed will be at, or near, the average of a large number of determinations by digestibility trials. It will not necessarily agree with the published result for a single feed, but, in view of the variability in the results of digestibility trials which was found by Schneider and Lucas (1950), the calculated figure is likely to be at least as near the truth as a single determination by digestibility trial. The term "apparent digestibility" is used in describing the protein digestibility obtained by digestion trials because the nitrogen in the faeces occurs in two forms, one the undigested protein of the feed and the other the waste metabolic nitrogen compounds. In order to measure the true digestibility of a feed it would be necessary to separate the metabolic faecal nitrogen from the undigested protein in the faeces, but this cannot easily be accomplished in the laboratory.

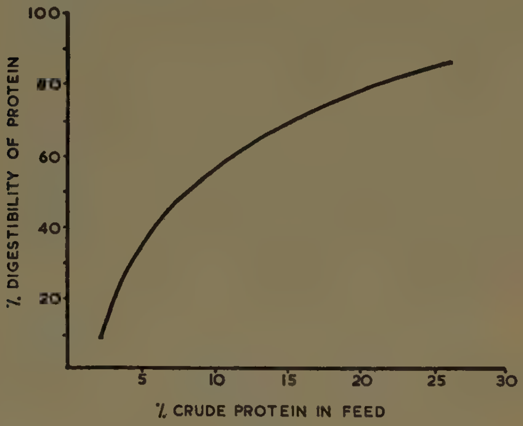

Fig. 1

The effect of crude fibre on the digestibility of protein by ruminants was studied by Glover and French (1957), who found that for normal feeds the effect is slight, and for all practical purposes the equation given above is satisfactory. On the other hand, with feeds in which the crude fibre/crude protein relationship is abnormal more accurate estimates of the digestibility of protein can be obtained from their modified equation,

% digestibility of crude protein = 5 + 60 log c.p. − 0.33 c.f.

which need not be considered further here.

The shape of the curve in Fig. 1 has explained some discrepancies which have appeared in feed evaluation and in feeding trials. For example, some nutritionists found that the addition of urea to a roughage feed raised its nutritive value for cattle and sheep, whereas others found little or no benefit from urea. The probable explanation is that the first group of workers added urea to roughages of low protein content, thus raising the protein content of the whole feed from say 5 per cent to 10 per cent. From the curve it will be seen that in this way the apparent digestibility of the protein would be raised from 34 per cent to 55 per cent, giving a marked increase in digestible protein. On the other hand, if urea is added to roughages with higher protein contents, such as those between 12 per cent and 15 per cent, the effect of the urea would be less evidence and might possibly be hidden in the experimental error. French (1957) showed that rations containing urea conformed to the curve, and that the equation can be applied to these, but he pointed out that urea can be absorbed from the alimentary tract and be excreted in the urine without taking part in the nutrition of the animal. The percentage of fed urea which will be absorbed as ammonia will be increased at higher levels of protein intake, and thus it seems likely that urea will have its maximum effect when it is added to rations which are low in protein. In this connexion, it is of interest that Johnson *et al.* (1942) found that the addition of urea to a ration containing only 6 per cent protein in amounts to produce the equivalent of 12 per cent crude protein in the ration produced a beneficial effect on growing lambs which could not be bettered by further urea additions, but which could be bettered by raising the true protein content of the ration.

Negative protein digestibilities are often recorded for feeds which are very low in protein, cassava meal being an example which is of particular interest in the tropics. Since cassava meal does not contain sufficient protein to maintain a ruminant, digestibility trials with it are usually carried out by the "by difference" method, in which a roughage, such as a good hay containing about 10 per cent crude protein, is used as a basal ration. The digestibility of the protein in this hay is determined first, then a trial is run with hay plus cassava meal, giving the digestibility of the protein in the mixed ration, and the results from the hay trial are deducted from those for the mixed ration to find the digestibility of the cassava meal. From the curve it can be seen that by adding cassava meal, with about 2.5 per cent protein, to a hay with 10 per cent protein, giving a mixed ration with, say 8 per cent protein, will cause a reduction in the digestibility of the protein of the mixed ration and, therefore, results obtained by difference are, in theory, certain to be negative. However, if the basal ration contained 15 per cent protein, and the hay plus cassava 13 per cent protein, the reduction in protein digestibility would be relatively small and the high experimental error associated with digestibility trials might mask the true result and give a positive digestibility of the cassava meal protein.

The use of the "by difference" method of evaluating concentrate feeds has frequently been criticized, but until now it has provided the only means of obtaining feeding values of materials which could not be fed alone in digestibility trials. It will be seen from Fig. 1 that a change of protein content of the feed causes a change in the digestibility of the protein, and that the digestibilities of the basal ration and the concentrate are not additive, as was once assumed. Thus groundnut cake, for example, would give different results with basal rations of different protein contents, as was shown by French *et al.* (1957) in the form of a table which is reproduced here as Table I.

Rogerson (1955–56) demonstrated that different results can also be obtained with groundnut cake by varying the ratio of basal ration to concentrate. Thus the evaluation of supplementary feeds by the "by difference" method can give at best only an approximate figure for protein digestibility, and a more useful measure is the total protein content of the mixed ration, from which the digestibility of the protein, and hence the percentage of digestible protein, can be calculated from the equation given above.

It seems, therefore, that the published figures for the digestible protein contents of roughages and concentrates cannot be accepted as accurate assessments, and that average figures derived from the equation are almost certain to be as useful as those obtained by digestibility trials. There is the added advantage that a single analyst can make 12 or more crude protein determinations daily as compared with a maximum of two results per month from digestibility trials. Rapidly growing grass can easily be evaluated at frequent stages of growth, and variations in the values for hays and silages from district to district or farm to farm can be checked. The values for mixed feeds can be obtained by calculating or determining the crude protein content of the whole ration, and the anomalies caused by negative digestibility coefficients are eliminated. Further, it is now possible to extend rapidly our knowledge of the feeding values of browse plants, which play a vital role in the ranching areas of East Africa. Dougall and Bogdan (1958) have described and analysed 37 browse plants from Kenya, many of which have high protein contents and, therefore, high nutritive values, unless their palatability is low. It is unlikely that any of these could be evaluated by digestibility trials, because they occur in sparsely populated areas, far from laboratory facilities, but the digestible protein can now be calculated from the crude protein content.

In Table II we give the average percentages of digestible protein, corresponding to a range of crude protein contents, calculated from the digestibility coefficients obtained from the equation.

TABLE I—DIGESTIBILITY COEFFICIENTS OF CONCENTRATES CALCULATED BY THE "BY DIFFERENCE" TECHNIQUE

(Proportions fed 88·2 per cent basal + 11·8 per cent supplement)

Crude protein in basal ration	Protein concentrate 40 per cent crude protein		Carbohydrate concentrate 3 per cent crude protein	
	% crude protein of mixture	Digestibility coefficient	% crude protein of mixture	Digestibility coefficient
6	10	72	5·7	+10
16	18·8	88	14·8	−56

TABLE II—AVERAGE PER CENT DIGESTIBLE PROTEIN BY CALCULATION

% crude protein in feed	% digestible protein	% crude protein in feed	% digestible protein	% crude protein in feed	% digestible protein
4	1·1	13	8·2	22	17·4
5	1·7	14	9·1	23	18·5
6	2·4	15	10·1	24	19·6
7	3·1	16	11·1	25	20·7
8	3·9	17	12·1	26	21·9
9	4·7	18	13·1	27	23·0
10	5·5	19	14·2	28	24·2
11	6·4	20	15·2	29	25·3
12	7·3	21	16·3	30	26·5

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REVIEW

THE NIGER AGRICULTURAL PROJECT, by K. D. S. Baldwin, published by Basil Blackwell, Oxford, 1957, 221 pp., price 27*s*. 6*d*.

This is a critical account of an experiment in African development at Mokwa, in Nigeria, which was financed jointly by the Colonial Development Corporation and the Government of Nigeria. The scheme, which was launched in 1949, was to develop an area of some 50 square miles of virtually uninhabited land near the small town of Mokwa, about 325 miles north of Lagos and 25 miles north of the Niger River. The project had as its aim a contribution to the increase in the production of groundnuts for export and of guinea corn (sorghum) for local consumption, the farming system to be mechanized as far as possible. The scheme was carefully planned and efficiently managed, but it was a failure, and in 1954 the Niger Agricultural Project Limited went into liquidation with a net loss of £123,494 to the Colonial Development Corporation. In order that the lessons learned at Mokwa should be available for future guidance and warning, the Corporation invited Mr. Kenneth Baldwin, of the West African Institute of Social and Economic Research to study the project, and for this he was given access to all records in London and Nigeria.

It is easy to condemn failure or to praise success, but it is difficult to bring out the good and bad points of a failure so that the lessons learned may be of value in future planning. The Groundnut Scheme, the Gambia Poultry Scheme, and the Niger Agricultural Project have all shown how difficult it is to change the pattern of tropical agriculture on a large scale. High costs of clearing and preparing land, and cultivation problems such as maintenance of tilth and of early sowing over large areas, have so far been limiting factors in large-scale mechanization of low-priced food crops. In this book Mr. Baldwin has critically examined the economics of the Niger scheme in relation to its agricultural problems, and is to be congratulated in presenting his findings in such a way that many of the mistakes need not be repeated in future development schemes.

D.W.D.

SMALL HOLDINGS ON THE TANGA COAST

A comparative study of land use in association with the sisal industry

By R. E. S. Tanner, Provincial Administration, Tanganyika

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This work was undertaken in 1955–57 in Pangani District to study the effects of the long-term alienation of large areas of land for sisal estates on the smallholding agriculture of the indigenous inhabitants. It is accepted that the areas at present occupied by sisal estates were unoccupied when they were alienated.

Under customary law, land can be obtained by inheritance or allocation from within a family already resident in the area, by clearing new land or by application to a landowner for permission to cultivate a part of his undeveloped holding.

Three sample areas were studied, and a census was carried out combined with the recording of the land holdings of each adult man and women as stated by them or the elders of the village. Subsequent to this, with the help of the Agricultural Department, these statements were checked against their actual land-holding and the difference recorded or corrected.

The first sample area was Mkwaja village, some ten miles from the nearest sisal estate with a large undeveloped hinterland. A compact group of about 140 houses, whose inhabitants were mostly related to each other, on a site inhabited for over a century.

The second sample area was Madanga village, situated between two sisal estates at a distance of about five miles, with a heavily cultivated neighbourhood but with plenty of uncut forest further away. A closely constructed village of about 200 houses, of which a high proportion were related, which had sprung up on a new motor road within the last 50 years.

The third sample was Mwera village sandwiched between two sisal estates with about 350 houses straggling along a motor road, where a very limited amount of land was available in the neighbourhood, and the village had sprung up as a result of the nearby estates.

It was assumed that change would be least visible at Mkwaja and in its exeme form at Mwera with Madanga occupying an intermediate position. No attempt will be made to study the theory of land rights and use other than is evidenced from their practical application in the sample areas. It was found repeatedly that informants of all ages talked about customs which had died away, as if they were still practised, so that in discussing the facts of their agricultural life there is often a strange air of unreality in their approach.

EMPLOYMENT IN THE VILLAGES

General (*see Appendix I*)

In all three sample villages migrant labour is available for all those who can afford to pay or reward services in kind. In Mkwaja there is a small colony of aliens who are employed in coco-nut plantations or in cultivation, although the latter is largely done by Zigua migrant labourers from 50 miles inland who visit the coast annually in numbers proportionate to the success of their previous maize harvest.

In Madanga, a certain amount of casual work is done on Sundays by labourers from the two nearby sisal estates, but the village itself has a substantial colony of migrant labourers from the Southern Highlands Province who are permanently employed on piece-work in the nearby coco-nut plantations and fields. The migrant labourers are entirely separate from those employed on sisal estates where they regard the work as too hard and the conditions of employment as unfavourable.

In Mwera there is no colony of migrant labourers as such but there are a large number of inferior workers available for whom sisal work had become too hard or too demanding, apart from the labourers who leave the estates on Sundays to pick up casual work in the neighbourhood.

In all three areas migrant labour appears to be the key to agricultural efficiency, and failure is often expressed in terms of not having sufficient means to pay for the necessary work to be done. It is not suggested that this state of affairs is a direct result of the local domination of the sisal industry, but that the ancient regime, real or imaginary, of aristocrats and slaves prior to the time of European suzerainty, has easily transposed itself into the locally born householder and his migrant labourers, for which the sisal industry is partly responsible, by providing a ready source of labourers which must inhibit the agricultural efforts of the local people.

A great deal of the life of these people is preoccupied with the gaining and maintaining of prestige through the generous use of money at weddings, funerals, circumcisions and other ceremonies. At the same time, it is recognized that anyone who has any pretensions to prestige must not be seen doing the hard physical work which in a previous but not forgotten era had been associated with slaves and the lowest classes of free men.

Thus it is seen that the income of these men is considerably strained both to gain prestige and to employ the workers, who alone can make it possible for them to get an income at all. This results in the majority falling cleanly between the two extremes with their fields inadequately worked and their pretensions unfulfilled. Mkwaja village, with the nearest sisal estate ten miles away, is the typical example of this attitude towards agriculture.

In both Mkwaja and Madanga, a small proportion of the men (19 per cent and 14.5 per cent) do not cultivate at all because they are employed locally as fishermen, petty traders, etc., and a higher proportion of the women (29.1 per cent and 27.1 per cent) do not cultivate because they are dependent on their husbands for whom they have no statutory obligation to work under Moslem law.

In Mwera village, which lies on the boundary of a sisal estate, a large majority of both sexes do not cultivate (65.3 per cent and 69.4 per cent) even though a much smaller proportion of the men (33 per cent) are classified as employed. This seems to suggest that the dominance of the near-by estate has suffocated the potential agricultural life of the community without at the same time providing or being the cause of providing employment for the landless majority. It must be remembered that these are not full-time sisal labourers as such, to whom the industry has obligations, but individuals who have set up on their own without the support of landed property or nearby relatives, a proportion of whom appear to become indigent by local standards. The position of the women may be even more extreme since over a third are always unmarried and do not cultivate and are largely parasitic on the community.

Although it is recognized that much of this condition is the consequence of any large measure of industrialization, there are, nevertheless, differences which put the people of Mwera at a disadvantage. Locally, there are no alternatives to sisal employment, since there is very little vacant land in the neighbourhood, whereas in a fully industrialized area there are numerous choices of employment, and in Madanga village, situated midway between two estates, every man has a choice between estate work and self-employment in agriculture, which seems to be both a stimulus and support to their activities.

Lastly, all three villages are a part of the one coastal social system which puts a high value on the gaining of prestige, and agriculture remains the best method for realizing these hopes. At Madanga village, the not too distant estates have stimulated the community into becoming agriculturally healthy and reasonably independent, but at Mwera, the adjacent estates have inhibited the possibility of local agriculture and the prestige-gaining activities developing therefrom.

Coco-nut Cultivation

Coco-nut plantation ownership is a visible sign of well-being and social status over the whole area for all those who wish to establish themselves as persons of consequence independent of the annual exertions of less happily propertied persons.

The increase in numbers and extent of coco-nut plantations is prevented by the absence of suitable vacant land and the unavailability of migrant labourers or the means to employ them. Owing to the variety of jobs which have to be done in turning coco-nuts into copra, no plantation owners can be independent of migrant labour even if they wished to be.

In Mkwaja village, ten miles from the nearest sisal estate, where there is ample land available for extension, only 37 per cent of the men and 13 per cent of the women owned plantations, and of these 64 per cent and 100 per cent respectively were obtained by inheritance or by marriage. Men had opened up plantations themselves (27 per cent) or purchased them (8 per cent) in the remaining cases. Those men who were employed, owned a higher proportion of the plantations than those who were self-employed.

In Madanga, where there is also ample land available for extension, only 47 per cent of the men, but the much higher proportion of 37 per cent of the women, owned plantations, and of those, 53 per cent and 95 per cent respectively were obtained by inheritance or by marriage. A higher proportion of men had opened up their own plantations (35 per cent) or purchased them (9 per cent). The self-employed men owned a higher proportion of plantations (65 per cent) than those who were employed (35 per cent).

This seems to suggest that the presence of estates in the vicinity may have been partly responsible for greater personal effort and initiative by men not directly connected with them, but that inheritance is still the principle means of obtaining plantations.

In Mwera, where there is little land remaining, a very small proportion of men (14 per cent) and women (0.3 per cent) own plantations, and of those 50 per cent and 100 per cent respectively were obtained by inheritance or kinship. Men had purchased 45 per cent of their plantations and the self-employed owned 66 per cent of the total plantations.

In the course of these investigations the information given by the people themselves was always checked against their actual agricultural activity, so that the proportion of lies could be assessed as an indication of agricultural stress. This amount of coco-nut cultivation seems to equate with the ambitions of the villages themselves, as only a small proportion of each sex felt obliged to give false information.

It seems that the best conditions for coco-nut cultivation exist in Madanga village, which is not in close association to sisal estates, and that, in general, cultivation is not done by employed men although ex-workers may have used their savings to open up plantations. Women have remained unaffected by local conditions in their ownership of plantations.

Rice Cultivation

Whereas coco-nut plantation ownership represents a secure old age and social standing in the economic scale of class status, a successful rice harvest is the means of giving the large feasts for marriage or circumcision, by which a family can increase its prestige. Although rice is the preferred food for almost everyone, its cultivation is not done by women in order to fill the household's granary, but as a partial security against the improvidence of their menfolk and the frequency of divorce.

In Mkwaja a succession of dry seasons has prevented any further rice cultivation, and in all areas the climate has a greater restraint on the rice crops than any other conditions.

In Madanga very few men and a high proportion of the women (45 per cent) cultivate rice. The majority of these fields were opened up by their present cultivators on vacant land.

In Mwera very few men again cultivate rice although a slightly higher proportion (15.5 per cent) of the women continue to do so, and it seems that this state of affairs is a source of stress because of the high proportion of the women (34 per cent) who gave false information. Almost all these fields were obtained on short loan from the local estate as the only suitable land lay within its boundaries.

Again Mwera village, immediately adjacent to a sisal estate, shows the most unsatisfactory situation.

Cassava Cultivation

In all three villages cassava is the staple crop of all those who wish to cultivate at all, not only because of the simplicity of its cultivation but because of its resistance to drought and flood.

In Mkwaja 62 per cent of the men and 68 per cent of the women cultivate cassava in fields which they opened up themselves. These men cultivating were almost all self-employed. Both sexes showed a low proportion giving false information.

In Madanga 77 per cent of the men and 40 per cent of the women cultivate cassava, and of these 30 per cent and 72 per cent respectively were obtained by inheritance or marriage. Men and women had opened up fields themselves in 62 per cent and 27 per cent of the cultivation. Self-employed cultivators were only just in excess of employed cultivators. In both sexes over 10 per cent gave false information, which suggest the beginnings of stress.

In Mwera 25 per cent of the men and 12 per cent of the women cultivated cassava, and of these 35 per cent and 38 per cent respectively were obtained by inheritance or marriage. Men and women had opened up fields themselves in 60.5 per cent and 50 per cent of the cultivation. Self-employed cultivators again were only just in excess of employed cultivators. In both sexes the high proportion of 28.5 per cent and 23.7 per cent of the total population gave false information which is evidence of definite stress in their agricultural life.

Again, the cultivation of cassava has been stimulated by Madanga village not being in too close proximity to sisal estates and definitely curtailed in Mwera where the village has developed as an appendage to a sisal estate rather than as a viable entity of its own.

CONCLUSIONS

1. There may be much similarity between the amount of agriculture done by slaves in the past and by migrant labourers in the present, as in both situations the owner or employer is inhibited from personal effort.

2. The locally born householder appears to have had much the same attitude of mind to slaves as he now does to migrant labourers, as he does consider hard physical work in his fields compatible with his desire to gain prestige.

3. The sisal industry is largely but now wholly responsible for the availability of migrant labour on which their agricultural system is largely dependent.

4. The presence of ample migrant labour, a high proportion which is not fully employed on sisal estates, itself a sign of stress in other areas, has largely prevented the people from developing self-reliance and a viable agricultural economy.

5. The presence of sisal estates in the locality appears to act as a beneficial stimulus to an agricultural community, but their close proximity causes such a dominance over the life of the community that it can no longer function agriculturally.

APPENDIX I

1956 CULTIVATING PATTERN BY INDIVIDUALS AND CROPS

	MKWAJA Distant from estates		MADANGA Estates in area		MWERA On Estate boundary	
	Men	Women	Men	Women	Men	Women
Not cultivating	23 (19%)	49 (29·1%)	31 (14·5%)	63 (27·1%)	220 (65·3%)	198 (69·4%)
Coco-nuts only	22	5	11	22	22	12
Rice only	—	—	—	27	—	40
Coco-nuts and rice ..	—	—	—	10	—	1
Cassava only	53	91	68	14	59	29
Coco-nuts and cassava ..	23	18	76	23	25	1
Cassava and rice	—	6	8	27	1	3
All three crops	—	—	13	30	—	—
Total cultivating	98 (81%)	119 (70·9%)	183 (85·5%)	169 (72·9%)	117 (34·7%)	86 (30·6%)
Total adult population ..	121	168	214	232	337	264
Cassava cultivators ..	76	115	185	94	85	33
Rice cultivators	—	6	21	104	1	44
Coco-nut cultivators ..	45	23	100	85	47	14

HERBAGE PLANTS AT SERERE EXPERIMENT STATION, UGANDA 1954–1957—I: GRASSES

By C. R. Horrell, Department of Agriculture, Uganda

(*Received for publication on 13th May, 1958*)

This paper gives a brief account of the grasses studied during the last three years in nursery plots at Serere. A second paper will deal with legumes.

The station is situated at 1° 32′ N.; 33° 27′ E., at altitudes between 3,600 ft and 3.700 ft. The rainfall averages 53.4 in. and is bimodally distributed with peaks in April/May and August/September. The dry season extends from December to March. Mean maximum temperature is 86.5° F. and mean minimum is 64° F. The soil is a sandy loam 2–3 ft. deep, overlying gravel and ironstone and derived from highly-sheared quartzite which is lacking in weatherable minerals (Ollier, 1957). The pH is 5–6 and the soil is low in base content, phosphates, sulphur and organic matter. Nitrogen content is low, being around 0.1 per cent. This soil has recently been reported (Dagg, 1957) to have one of the lowest water infiltration and percolation rates yet found in East Africa. The dominant species in the natural grassland community (fire climax) is *Hyparrhenia rufa* (Langdale-Brown, 1958). Hosking and Stephens (1941) published a list of indigenous grasses of the area. These mainly occur in the following genera: *Brachiaria, Chloris, Cynodon, Digitaria, Eleusine, Eragrostis, Hyparrhenia, Imperata, Loudetia, Panicum, Setaria, Sorghum, Sporobolus*.

The primary object of the present pasture research programme is to produce a grass-legume association for use in a ley of three years duration in a mixed farming system. Complementary to this work, studies are being made on certain fodder grasses for dry season grazing, and minor observations have been made on lawn grasses.

In evaluating grasses in the nursery special attention has been paid to persistence, production, habit, seeding ability and to a lesser extent, palatability. Those that have been studied in most detail are starred in the text. The origin of each species is quoted after its name.

The species have been arranged in order of tribes (after Hutchinson, 1944), since Hartley and Williams (1956) attach a certain amount of importance in plant testing work to taxonomic affinities at tribal and specific levels. It is apparent that the tribes *Chlorideae* and *Paniceae* have provided all the most useful material with the exception of *Hyparrhenia rufa* which is a member of *Andropogoneae*.

ERAGROSTEAE

Eragrostis chalcantha Trin. SR.403. E. Africa

This indigenous species was discarded because of low productivity and non-persistence.

Eragrostis curvula (Sehrad.) Nees. SR. 5621 Weeping Love Grass. E. Africa

This perennial, tufted, fine-leaved species grows well under poor, dry conditions and may have limited application. It is an important sown species in South Africa where seed is in commercial supply. Although it is easy to establish, only a few seed heads are produced here.

Eragrostis superba Peyr. SR.404 Wilman's Love Grass. E. Africa

This grows well from seed and is perennial. The local type is unproductive, however, and before further work is done selection and introduction of improved strains would be necessary. It may be of particular use in drier areas.

PHALARIDEAE

Phalaris tuberosa L. SR.577 Toowoomba Canary Grass. Mediterranean

A tufted perennial which grew poorly and is of little agronomic interest.

CHLORIDEAE

**Chloris gayana* Kunth. Rhodes Grass. E. Africa

This has been used in leys at Government experimental stations for many years. It is a perennial stoloniferous species, and forms a good soil cover which is one of its major attributes. It is easily grown from seed, though the quality of the seed used so far has often been poor for various reasons including severe damage at flowering by thrips. In the absence of seed supplies, it can be established quickly from widely-spaced "sets", under conditions of good rainfall and medium soil fertility. "Teso" Rhodes grass is excellent on good soils in Uganda but unproductive on the poorer soil types where it becomes very stemmy and barely persists after the second year. Normal dressings of sulphate of ammonia can double yields at Serere. Yield without fertilizers compares equally with African foxtail but is considerably less than that of Guinea grass.

Eighteen introductions have been grown; the outstanding one, S.R.5316, is superior to the others in production, leafiness and palatability.

Chloris myriostachya Hochst. SR.5483. E. Africa

This perennial is native to the drier areas of Uganda. It grew rapidly from seed and produced nearly as much as Rhodes grass. It remained tufted, however, and deteriorated over a period of three years; because of its good seeding qualities it might be useful for obtaining an initial cover in dry, overgrazed areas.

**Cynodon dactylon* (L.) Pers. E. Africa

Several small types of this stoloniferous perennial have been introduced for lawn trials, as it is excellent for this purpose where fertility is good. A local heavy-seeding type is one of the most serious weeds in local cultivation. It grows strongly round kraal sites where, it is believed, the seeds are dropped in cow dung, and it colonizes bare patches on hard soil and earth roads. Most types are too small and unproductive to be important for grazing but larger ones exist. The famed Coastal Bermuda variety has recently been introduced, but it is not very productive under low fertility conditions. Most varieties seed sparingly but the seed produced is often of high quality. Germination is greatly improved by scarification of the seed before sowing.

**Cynodon plectostachyus* K. Schum. E. Africa

This is another stoloniferous perennial similar to *C. dactylon* in form and, like the latter, appears to require high fertility for good production. The giant variety, SR.5560, is being bulked for use in long-term leys or permanent pasture in more fertile areas; it is drought-resistant and produces a small amount of seed of good quality. It is not so palatable as Rhodes or Guinea grass.

Cynodon transvaalensis Burtt Davy SR.5553. E. Africa

This is a very tiny species of similar habit to *C. dactylon*, and although it is a good lawn grass in cooler climates, it is not satisfactory here.

MELINIDEAE

**Melinis minutiflora* Beauv. SR.4013 Molasses Grass. E. Africa

Molasses grass occurs wild mostly at altitudes not less than 5,000 ft. It is a perennial sward-forming grass which roots at the nodes and, under good management, forms a thick mat. It contains an essential oil, burns rapidly and is killed out by fire. The grass is palatable, seeds well and produces heavily if not defoliated too frequently but it tends to bunch and eventually disappear under grazing. A vigorous type, SR.5561, has been recently selected and awaits testing.

PANICEAE

Brachiaria brizantha Stapf. SR.545 and 546 Signal grass. E. Africa

Strains vary greatly. SR.545 is a semi-erect type which is particularly drought-resistant. It roots at the nodes but is slow in producing a complete cover. The leaves are broad, dark green and slightly hairy. Flowering is fairly good but seeding poor; the proportion of stem to leaf is small as generally with this species; productivity appears to be good. SR.546 is a less productive prostrate form which rapidly produces a ground cover from sets. In colour it differs markedly from SR.546, being yellowish-green. Very few flowering heads are produced. It is neither very vigorous nor drought-resistant.

Selections of *Brachiaria brizantha* could be extremely useful, but no good seeding strains are known.

Other local species are: *B. decumbens* Stapf. which is similar in appearance to *B. brizantha* but less productive; *B. soluta* Stapf. and *B. fulva* Stapf. which are hairy and relatively unproductive but nevertheless quite palatable.

**Cenchrus ciliaris* L. African Foxtail. E Africa

There are considerable differences in form and productivity within this species ranging from the least productive prostrate "pasture type" to a more productive stemmier hay type. The species is one which is well worth developing, particularly for drier areas. It yields equally with Teso Rhodes grass but not so well as several other grasses. Production is better spread over the year than with other species and is maintained better in the third and later years. It is palatable except when in a very advanced stage of maturity; if allowed to reach this stage it must be defoliated—burning is satisfactory—before any useful new growth can be expected. Flowering dates vary considerably with strain; seeding is good. Seed germination benefits from a 12-month storage period; it has been shown in the laboratory that germination is greatly increased by removal of the glumes; in practice this could be carried out with a suitably regulated hammer mill.

Fourteen introductions have been grown, the best being SR.5626 and SR.5411.

Digitaria pentzii Stent. SR.401. S. Africa

A turf-forming grass which becomes too tussocky at Serere for lawns and burns badly during droughts.

Digitaria swazilandensis Stent. S.R.415 Swazi grass. S. Africa

This is another turf-former which is used for lawns in some parts of the world, but is unsuitable here for the same reasons as *D. pentzii*.

Echinochloa pyramidalis Hitchc and Chase. SR.453. E. Africa

This is a tall reed-like perennial which normally inhabits swamps. It has been grown on dry land fairly successfully but appears of little interest for cultivation.

Panicum deustum Thunb. SR.454. E. Africa

A tall perennial which is not suitable for grazing; it is not as productive as *P. maximum* and is very susceptible to leaf rusts.

Panicum infestum Aderss. ex Peters. SR.455. E. Africa

This is a vigorous, medium-sized, perennial tussock grass which inhabits the lake shore locally. It is very hairy and its tussock-forming nature makes it unsuitable for cultivation.

**Panicum maximum* Jacq. Guinea grass. E. Africa

Guinea grass is dominant on the better soils in large parts of Uganda during the first two or three years after cultivation. It is one of the most promising species for use in leys, being highly productive and having a high feeding value which does not deteriorate so rapidly as that of most grasses with advancing age. It is also very palatable and has a low proportion of stem to leaf. Guinea grass can be satisfactorily established from seed if harvesting is carried out carefully and the seed is suitable for machine planting. It is drought-resistant and suitable for dry season foggage ("standing-hay"). Its vigorous growth habit allows it to compete well with the more aggressive legumes. Since it is tufted in habit it should preferably be sown in association with a "bottom" grass or legume to provide soil cover. A number of strains are now under test.

Paspalum dilatatum Poir. SR.5423 Dallis grass. S. America

This is a tufted perennial which is unproductive and therefore useless.

**Paspalum notatum* Fleugge. SR.212 and others. Bahia grass. America

Bahia grass is widely used in the Protectorate in erosion control work, for sports grounds and for lawns. It is planted vegetatively because seeding is poor though it can be induced to seed a little by first burning off. It is unproductive for grazing. It forms a dense turf which can be ploughed out satisfactorily but is difficult to remove by hand digging. Very depressed crop yields are obtained in the first year after its removal. Several strains are under test for lawn purposes; a fine-leaved one, SR.5717, appears to be the best and is easier to dig out than other strains—an advantage both for propagation and elimination.

Paspalum scrobiculatum L. SR.5429. E. Africa

A perennial, low-growing, tufted grass which is a poor producer and suffers severely during dry spells. The small local type, *P. scrobiculatum* L. var. *commersonnii* Lam. is a common weed in abandoned cultivation and in leys that have been overgrazed. It seeds well, producing seed of good quality.

Paspalum urvillei Steud. SR.5739 Vasey grass. S. America

This is a tufted, upright perennial with broad, soft leaves and very little unpalatable stem. It produces seed of good quality and may be of interest for one- or two-year leys.

Paspalum virgatum L. SR.5428, SR.4015. S. America

This is an exceedingly coarse, large, densely tufted perennial which was completely unpalatable except when very young. Seeding was heavy and it spread rapidly from self-sown seed. It showed signs of becoming a nuisance and was eliminated.

Pennisetum pedicellatum Trin. SR.5471, 5472. W. Africa

This annual is reported to be very productive in West Africa. At Serere, germination was excellent and it rapidly produced dense herbage about 18 in. high. It then went to seed rapidly, and soon dried off. Self-sown seedlings developed on the plot during the following rains. Though it has little application here, in dry areas it might be of use during the rainy reason if it continued to maintain itself by self-seeding. In Karamoja there is an area which is grazed under a nomadic pastoral system; overgrazing here during the rainy season creates a problem which grasses such as this might alleviate.

Pennisetum polystachyon Schult. SR.4016. E. Africa

A common local grass which is a short-term perennial but appears to have possibilities for the development of a longer term strain. Its main advantages are its excellent seeding capacity, rapid germination and good early production. The grass is somewhat unpalatable but selection might overcome this disadvantage. It is killed out rapidly by too heavy grazing.

**Pennisetum purpureum* Schumach. Elephant grass. E. Africa

This grass was introduced from Buganda Province where it is a dominant wild species. It is a heavy fodder-producer and is being investigated for special-purpose grazing; stem cuttings are planted in wide rows and the grass is allowed to grow through the wet season with no defoliation, in order to build up the plant reserves. It is then cut down a month before the rains finish and it can continue to produce through two or three grazings during the dry season. It is very deep-rooted and has a beneficial effect on soil fertility. The main drawback of this grass in peasant farming is the difficulty encountered in ploughing it out when required. Heavy grazing throughout the last year of its cultivation will kill it, however, and render the task easier. Several varieties are being tested including "Uganda hairless".

Setaria longiseta. SR.5431. E. Africa

A small tufted unproductive grass which persisted only for two seasons and then was eliminated as being of no interest.

**Setria* spp. Beauv. E. Africa

Twenty-one *Setaria sphacelata* and *Setaria splendida* forms have been grown. They probably all belong to one very variable species. Some forms are slightly rhizomatous, others low-growing and densely tufted, others of a tall "hay" type and loosely tufted. Some of the low-growing and medium-height forms, which are generally found on black soils of seasonal swamps, are relatively unpalatable. Forms approaching the so-called *S. splendida* are very palatable and highly productive, and one is considered a potentially useful fodder grass. Seed is produced but heads are often infected with a fungus and are also subject to depredation by birds. The commercial variety, "Nandi", from the Kenya Highlands, is not very satisfactory here.

Stenotaphrum secundatum Walt. (O. Ktze) Tropical sea shores

This is a short, stoloniferous turf grass. It suffered badly from drought in the nursery every time there was a short, dry spell. A further plot at a cattle watering point where the soil was fertile and continually moist grew vigorously and was continuously grazed heavily. In wetter situations it might be suitable for lawns since it produces a good ground cover. It is not productive enough for pasture. It did not set seed.

ANDROPOGONEAE

Andropogon schirensis Hochst. ex A. Rich. SR.431. E. Africa

A dense, tufted, coarse perennial of no interest for cultivation.

Bothriochloa insculpta A. Camus. SR.544. E. Africa

This is a perennial stoloniferous grass which forms a fairly good cover like that of Rhodes grass. It is very stemmy and has narrow, bluish-coloured leaves. It is palatable but is less productive than Rhodes grass. Seeding is good.

Bothriochloa glabra A. Camus

Is tufted, coarse and unpalatable.

Cymbopogon citratus Stapf. SR.302 Lemon grass. Probably India

A tufted perennial which is unpalatable. It is grown on a small scale on one or two estates in Uganda for lemon oil production and it was used by Africans for making a "tea" drink and as a skin deodorant. Around the 1930's it was in use for wash-stops in perennial crops but had to be given up because it was so easily destroyed by ants.

Eremochloa ophuroides. SR.405 (Centipede grass). S.E. Asia

A lawn or turf grass from cooler areas which is unsuited here. It failed to seed and growth was poor.

Hyparrhenia filipendula Stapf. SR.407. East Africa

This is a tufted perennial, rather hairy and not of interest as a cultivated grass. It is a dominant wild species in many areas. It was found to recover poorly after defoliation.

**Hyparrhenia rufa* Stapf. Jaragua grass. East Africa

Jaragua is a tall, tufted perennial which dominates the local fire-climax community. It is very productive and also very palatable. Towards the end of the season it throws up woody flowering culms. This is difficult to control by management but selections are being made for leafiness and late flowering. The species is considered to have great potential use for cultivation; it is already in use in South America where it was introduced.

Sorghum spp.

S. almum L. and *S. sudanensis* (Piper) Stapt. have been tried without success. They were unproductive of forage and suffered severely from leaf diseases.

Sorghum vulgare Pers. is a major crop in this locality.

DISCUSSION

Earlier accounts of grass species-testing in the north and east of Uganda have been given by Martin and Badcock (1937) and Hosking and Sephens (1941). These accounts, plus the present work, have provided considerable information on the suitability of species for cultivation. Profitable comparisons have been made with the work of Bogdan (1954) at Kitale, Kenya.

A few grasses from South America remain to be tested, but apart from these it is clear that the major ones worth considering for development in this zone of Uganda are the following:—

Chloris gayana	for leys.
Cenchrus ciliaris	
Cynodon plectostachyus	
Hyparrhenia rufa	
Pennisetum purpureum	for dry season supplementary grazing.
Setaria spp.	
Paspalum notatum	for lawns.
Cynodon dactylon	

This list includes all the grasses that have so far been reported to be of interest for cultivation in the dry tropics with the exception of *Melinis minutiflora* which tends to be restricted to the cooler areas. An excellent range of material for the conditions of north and east Uganda is contained among these species. A great deal of investigation is now necessary on establishment, management and evaluation of these grasses. It is to be expected that, as this investigation proceeds, further elimination of species will be possible, so making for greater concentration and effectiveness of research and extension resources.

Finally, a plea is made that there may be a place for grasses that are easily propagated vegetatively as opposed to those that are conventionally established from seed. In Uganda, where, at present, farmers' resources, skill and ability are low, the production and use of quality grass seed is surrounded by practical difficulties. Further, it has been found that establishment of pasture from seed is tricky and failures are many, due to frequent, unpredictable, heavy rain showers, rapid and frequent dessication of the soil surface where the seeds lie, and in some cases, severe surface panning. It is hoped that research and practical experience will conquer these problems in due course. In the meantime, however, a good stoloniferous grass might be vegetatively propagated with very little more labour and expense than conventional seeding. Ten man-days are required to hand-harvest 20 lb. of Rhodes grass seed which is commonly broadcast at 20 lb. per acre. Twelve man-days can suffice to plant an acre of grass by hand, vegetatively, at 4 ft. × 3 ft. spacing; and good establishment is certain if the planting is carried out during rainy weather. Considerations such as this must not be neglected in evaluation and final choice of species for extension on to peasant farms; this might possibly make improved strains of *Cynodon plectostachyus* and *Chloris gayana* the best propositions for leys, despite the fact that *Panicum maximum* and *Hyparrhenia rufa* are considerably higher-yielding species.

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DEAD TOP IN KENYA PINE PLANTATIONS

By I. A. S. Gibson, Forest Department, Kenya

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In the majority of countries where *Pinus radiata* D. Don has been introduced as a timber tree, *Diplodia* die-back has proved to be a disease of some consequence. Indeed, in the Union of South Africa and in Southern Rhodesia the establishment of this species has been considerably restricted following damage from this disease. In Australia, New Zealand and North America, where the disease has been known from a comparatively early date [1, 4], it has been the subject of several detailed studies. [3, 4, 8, 10, 12, 14, 15, 17.]

The symptoms of *Diplodia* die-back have been generally described as an initial failure of the leading shoot to make proper growth followed by a generalized browning and death, first of the needles and then of the whole shoot. The needles are largely cast and the affected shoot may bend over. Profuse resin exudation often accompanies death, the bark is thrown into ridges, and pycnidia of the fungus, *Diplodia pinea* (Desm.) Kickx. may be found bursting through the dead bark with an accompanying blue-staining of the dead sapwood. Death of the whole tree may rarely occur, either from downward spread of the fungus from an infected tip or from the establishment of *D. pinea* at branch crotches low down on the main stem [3]. A wide range of pine species are reported to be affected by this disease of which *P. radiata* is the most susceptible.

The association of *D. pinea* with die-back of pines in those instances quoted has been sufficiently constant to suggest that it may be acting as a primary pathogen. Because of this, numerous experiments have been made to test the pathogenicity of this fungus towards pines. These have shown that the fungus can only invade uninjured tissues under conditions of high humidity and inoculum concentration; injury of the tissues by such factors as hail or insect damage [6, 8], or the reduction of vigour of the host by causes such as excessive competition for soil moisture [2, 6, 10, 12, 17], have been found to facilitate invasion by the fungus. This is further supported by field observations [3, 7, 8, 17]. It should be noted that *D. pinea* can be mildly pathogenic to pine seedlings [3, 13].

DEAD TOP OF PINES IN KENYA

With the extension of the cultivation of *P. radiata* as a softwood crop in Kenya, some concern was felt regarding the risk of loss from *Diplodia* die-back. A careful watch was kept on this account, and a die-back of leaders was reported from time to time corresponding to a great extent to this disease. However, examination of these dead leaders failed to show the presence of *D. pinea* (or any other pathogen), or the presence of excessive resin exudation reported as typical of *Diplodia* die-back elsewhere. At the beginning of 1957 the study of the local condition, known as "Deap Top", was extended into a full survey of Kenya pine plantations to determine the severity of the disease and the probable extent to which it might be related to *Diplodia* die-back.

METHOD OF SURVEY

This was carried out by Divisional Staff of the Kenya Forest Department in collaboration with the Mycological Section. All plantations were visited and examined for the presence of dead leaders, either from a point of vantage or by a walk through the area; those trees damaged by animals, *Armillaria mellea*, or ants' nests were discounted in this examination, leaving those with dead leaders from less easily discernible causes. Where these were found in a plantation, a count was made of at least 200 trees to obtain a rough figure for frequency of the disease. Using the result of this count, each plantation was classified into the following four grades:—

Nil.

Low (frequency less than one per cent).

Moderate (frequency between one and three per cent).

High (frequency more than three per cent).

Specimens of dead tops were collected in pairs, selected to show early and late stages of the condition, for examination for fungal associates. The results obtained in this way are discussed in detail below.

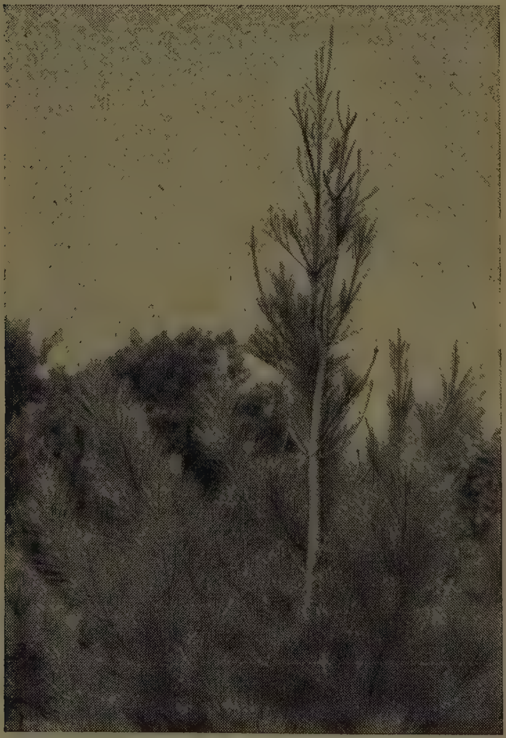
Symptoms of Tip Necroses of Pines Collected

The specimens received could be divided into two small groups and one large group on the basis of the symptoms given below.

(*a*) *Insect Damage.*—This was found associated with the defoliator *Orgya mixta* in two specimens and it was assumed that others with similar symptoms were probably damaged by this insect. Needles appeared irregularly chewed and were largely cast in the affected region; some necrosis of the shoot was found where damage was severe. This damage was only reported a few times and was regarded as relatively unimportant.

(*b*) *Split Leader.*—This was also found only occasionally and appears to be due to a swelling of the shoot near the tip causing it to split longitudinally; some resin flow is associated and needles are cast in the affected region. There is no tendency for the condition to spread in the tree, neither is there immediate necrosis; should the shoot die it is replaced by growth of a lateral.

(*c*) *Dead Top.*—This was by far the most frequent set of symptoms found in the survey and it was also these that approximated most closely to the symptoms of *Diplodia* die-back. The early stages are typified by the death and casting of needles leaving a shoot which is often largely turgid and green. Later, these sappy tissues tend to collapse and turn brown in patches which eventually coalesce; the brown coloration penetrates the internal tissues to the pith in places. The shoot ultimately dies, the bark becomes loose and falls away, by which time the whole is fairly heavily colonized by insects and fungi with occasional internal blue-stain. Rarely, this condition may be found starting at the first or second node and not at the tip of the tree. It was this condition that formed the subject of the survey and subsequent investigations.



Dead Top in pine. The leading shoot has died and a side shoot has taken over the lead

FIELD DISTRIBUTION

Table I shows the overall results obtained in the survey for incidence of Dead Top in three regions in each of the two Kenya Conservancies. *P. radiata* and *P. patula* have been separated in this statement, and each species shows a greater incidence of Dead Top East of the Rift Valley. Within that Conservancy the rather small sample in the region of Nyeri and Embu shows the highest incidence; this may be partially due to the neglect of thinning during the Emergency, leaving an excessive number of affected trees standing, but in spite of this the region is regarded as the worst affected.

Table II gives results related to age of plantation, *P. radiata* and *P. patula* again being the species treated. In considering these figures, account must be taken of thinnings which may be assumed to start at the sixth or seventh year, continuing every two to three years, and which will be effective in removing the great majority of trees with Dead Top. From these figures, the onset of Dead Top appears to coincide roughly with canopy closure and that after about the tenth year the rate of incidence may slowly decrease.

The marked difference in susceptibility between *P. radiata* and *P. patula* has already been shown in Tables I and II where it exists irrespective of age or site. Results for species not so extensively planted show that Dead Top occurs in *P. taeda*, *P. halepensis*, *P. caribaea* and *P. canariensis* while it has not been observed in *P. pinaster*, *P. longifolia*, *P. pseudostrobus*, *P. ponderosa* or *P. montezumae*. Figures for these are not sufficient to make valid comparisons, but it is notable that the greatest range of species with Dead Top was recorded in the area where the highest incidence of the disease was found.

In three sites a note was made on the relation between tree size (based on girth measurements) and Dead Top incidence. Measurements were made of affected trees and those unaffected trees in its immediate neighbourhood, but comparison showed no marked difference between these. The tendency for *P. radiata* in its younger stages to send up long unbranched leaders seems to be associated with Dead Top in young trees in all regions: a general tendency for cases of Dead Top to be more frequent at the bottom of a sloping site has also been noted.

Fungal Associates of Dead Top

Of the two minor conditions described above a species of *Pestalotiopsis* was found associated with insect damage while nothing more than superficial saprophytes (*Alternaria* and *Cladosporium* spp.) were found on tissues damaged with Split Leader. In all, 119 specimens of Dead Top were examined and a note kept of the major fungal colonists where these were found. The most frequent of these were *Pestalotiopsis* spp., of which *P. virgatula* Kleb. and *P. stictica* Berk. & Curt., *P. maculiformans* (Guba e. Zeller) Stey., *P. funerea* (Desm.) Stey., and *P. gigas* Stey. have been identified. *Sclerophoma pithyophila* (Corda.) v. Hohn was next in frequency and is known to be peculiar to this type of substrate although not as a pathogen. Other genera found from time to time to be dominant included *Cladosporium*, *Fusarium*, *Penicillium*, *Trichoderma*, *Aspergillus* and *Alternaria*. Few of these isolates could be regarded as likely secondary pathogens with roles similar to that of *Diplodia pinea* in *Diplodia* die-back. However, in spite of this, inoculation trials were carried out at the E.A. Agriculture and Forestry Research Organization, Muguga, in the open and in the glasshouse using a range of fungi obtained from Dead Top specimens. In the field trial a range of 14 isolates, including six of the *Pestalotiopsis* spp. *P. virgatula*, *P. funerea*, *P. gigas*, *P. maculiformans*, two of *Sclerophoma pithyophila*, two *Cladosporium* isolates, two *Fusarium* isolates, one *Alternaria* and one *Diplodia* (not *D. pinea*) isolate were used. Inoculations were made using thick spore suspensions applied to the leaders of 18-month-old *P. radiata* which had either been damaged by removal of some needles or by freezing with an ethyl chloride spray or had been left untreated. After application of inoculum the leaders were enclosed in polythene bags for 24 hours; inoculation was carried out in the late afternoon. Inspection of the treated shoots was made two months later but no sign of invasion was found by any of the fungi used. Later, smaller experiments on similar lines were made in the glasshouse using ten-month-old and four-month-old *P. radiata* which had either been left untreated or damaged by an ethyl chloride spray. Spore suspensions of *Pestalotiopsis* spp. were used as inoculum, inoculated plants being enclosed in polythene bags as in the previous experiments. Appropriate controls were included in all experiments.

The failure to detect any signs of pathogenic behaviour in the isolates tested conforms with the observation that most were obtained from the later stages of Dead Top; few fungal colonists were found at the earlier stages when damaging secondary invasion would be expected.

It was concluded from this investigation that *D. pinea* did not act as a secondary invader of dead or moribund pine leaders in Kenya and that there was no other fungus carrying out a similar role. This might well arise either from a general absence of the fungus from Kenya or from specialized conditions existing in the region of the leader preventing invasion. To determine which of these solutions might apply, a survey was made of litter samples collected from a range of 55 pine plantations. *D. pinea* is normally a pine litter saprophyte and it was considered that should it exist in Kenya it would be found on this substrate. Much the same range of genera were found on this substrate as on Dead Top specimens but in different proportions. *Sclerophoma pithyophila* occurred with about the same frequency as *Pestalotiopsis* spp., with *Fusarium*, *Alternaria* and *Camarosporium* occasional. Note was only taken of fungi found sporulating on the dead twigs and needles. Two records were obtained from these specimens of a *Diplodia* sp. but this did not correspond to *D. pinea*. A similar isolate had been made from Dead Top occurring in *P. radiata* in the E.A.A.F.R.O. arboretum at Muguga, which was not included in the survey. This fungus was tested for secondary pathogenicity in the trials described above with negative results. From the results of the litter survey it was concluded that *D. pinea* was at least very rare in Kenya, possibly due to conditions which did not permit its establishment as a successful litter saprophyte.

Discussion and Conclusion

The survey and related investigations have shown that Dead Top of pines is widespread in Kenya but very rarely assumes serious proportions. Individual trees are seldom extensively damaged and no instance is known of a tree dying as a result. In many respects the symptoms of Dead Top and *Diplodia* die-back are alike and where differences exist these may well be ascribed to the absence of the secondary invader *D. pinea.* A condition particularly prevalent in *P. radiata* has been described from Australia which seems to correspond closely to Dead Top in Kenya. This has recently been investigated [10] and it has been shown to be due to restriction in water supply. That Dead Top in Kenya may well arise from similar causes is supported by the onset of the condition at canopy closure when competition for water might be expected to become more acute, and by the greater incidence of Dead Top generally east of the Rift Valley, where rainfall is less evenly distributed than it is west of the Rift Valley.

The absence of *D. pinea* from Dead Top and pine litter in Kenya is thought to be at least partly due to the relatively high optimum temperature for growth of this fungus. The only data available on this are the records of Purnell [12] who gives the optimum for mycelial growth in culture at 85° F. (28.5° C.) with a complete failure of spore germination at 50° F. (10° C.), implying a rapid falling off in activity as temperatures decrease. Accounts of severe attacks of *Diplodia* die-back in South Africa, Southern Rhodesia and Australia, associate these with periods of high temperature and humidity, which might be expected from Purnell's figures. Data obtained for relative humidity and temperatures from four stations situated at locations corresponding to Kenya forest areas (Table III), show temperatures averaging well below those optimal for *D. pinea* and periods of maximum humidity corresponding to those of lowest temperature, a combination of conditions likely to be unfavourable to the fungus. Following this argument the effects of a range of temperatures on the growth of isolates from Dead Top specimens have been examined. Fourteen isolates belonging to five genera were used and each was grown in quadruplicate on tubed slopes of two per cent malt agar at the following temperatures: 15°, 22–24°, 25–27°, 27–29°, 30–32° C. Measurements of linear mycelial growth down the tubes were made at three intervals of two days and results obtained used to indicate optimum growth temperatures shown in Table IV. It will be seen that the majority of these approximate to temperatures found in Kenya forest regions and it is reasonable to assume from this that fungi recorded as associated with Dead Top are more suited to the environment than *D. pinea* which does not prove to be a successful competitor.

Finally, the evidence discussed above is not regarded as providing complete proof that *Diplodia* die-back cannot occur in the Kenya highlands, but it does indicate that it is much less likely than previously supposed. The present study does not take into consideration those parts of the Coast in Kenya and the areas in Tanganyika and Uganda planted to pines. It might be considered worth while, later, to extend similar studies to these areas.

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TABLE I—REGIONAL DISTRIBUTION OF DEAD TOP IN PINUS RADIATA AND PINUS PATULA

Region (Forest Divisions)	*Pinus radiata* Plantations showing:—				*Pinus patula* Plantations showing:—			
	No Dead Top	Less than 1% Dead Top	Between 1% and 3% Dead Top	Over 3% Dead Top	No Dead Top	Less than 1% Dead Top	Between 1% and 3% Dead Top	Over 3% Dead Top
Nairobi	40	27	2	1	46	3	0	0
Nyeri and Embu ..	6	5	4	2	26	2	1	0
Thomson's Falls ..	11	9	8	2	10	0	0	0
Total (East Rift) ..	57	41	14	5	82	5	1	0
Londiani South* ..	25	10	1	0	19	4	0	0
Londiani North† ..	37	8	2	0	34	0	0	0
Eldoret	29	4	1	1	18	0	0	0
Total (West Rift) ..	91	22	4	1	71	4	0	0

*Molo, Mariashoni, Elburgon and Nessuit Forest Stations;
†Maji Mazuri, Sorghet and Londiani Forest Stations.

TABLE II—THE EFFECT OF AGE OF PLANTATION ON INCIDENCE OF DEAD TOP

Age Group (Years)	*Pinus radiata*		*Pinus patula*	
	Percentage of plantations found with Dead Top	No. of plantations examined	Percentage of plantations found with Dead Top	No. of plantations examined
0–3	8·2	73	0	45
4–6	34·8	89	4·6	62
7–9	68·0	72	11·1	46
10–15	56·4	39	10·0	10
16 and over	41·7	24	—	—

TABLE III—MONTHLY MEAN TEMPERATURES AND RELATIVE HUMIDITIES AT FOUR STATIONS TYPICAL OF KENYA HIGHLAND FOREST AREAS

Station	Altitude (ft.)	Month	Temperature °F		Relative Humidity %		Remarks
			Max.	Min.	Taken at: 0800 hrs.	1430 hrs.	
Equator	9062	Feb.	69·3	46·2	69	37	Month of max. temperature.
		July	60·3	46·1	84	74	Month of min. temperature.
		Aug.	60·7	46·0	84	75	Month of max. humidity.
Eldoret ..	7050	Mar.	78·3	50·1	61	33	Month of max. temperature.
		July	69·7	48·8	82	60	Month of min. temperature. and max. humidity.
Molo ..	8300	Mar.	73·0	44·2	70	40	Month of max. temperature.
		July	64·9	44·2	84	67	Month of min. temperature.
		Aug.	65·6	44·4	84	68	Month of max. humidity.
Ol Joro Orok	7800	Feb.	75·3	41·8	61	30	Month of max. temperature.
		Aug.	66·3	42·5	84	66	Month of min. temperature.
		July	68·7	43·1	84	58	Month of max. humidity.

TABLE IV—OPTIMUM TEMPERATURES FOR MYCELIAL GROWTH ON 2 PER CENT MALT AGAR FOR FOURTEEN FUNGAL ISOLATES FROM SPECIMENS OF DEAD TOP

Genus	No. of Isolates	DISTRIBUTION OF OPTIMUM TEMPERATURES				
		(°C.) 15	22/24	25/27	27/29	30/32
		(°F.) 59	72/75	77/81	81/84	86/90
Cladosporium	3	0	0	2	0	1
Fusarium	2	0	0	2	0	0
Pestalotiopsis	6	0	4	2	0	0
Sclerophoma	2	0	0	1	1	0
Diplodia	1	0	0	0	1	0
TOTALS..	14	0	4	7	2	1

DISTRIBUTION OF THE COMMON BROWN TICK IN KENYA

By A. J. Wiley, Veterinary Department, Kenya

(*Received for publication on 21st March, 1958*)

The common brown tick (*Rhipicephalus appendiculatus,* Neumann (1901)) is one of the most dangerous vectors of animal disease in East Africa. Not only is it the usual carrier of East Coast fever and sometimes of redwater in cattle but the species is also the vector of Nairobi sheep disease and, in other countries, of louping ill of sheep, and a tick-bite fever of man.

Lounsbury first experimentally transmitted East Coast fever in 1902 using the adults of *R. appendiculatus* which had engorged as nymphae on an infected animal. This was carried out in Rhodesia and it was here that the disease first came to be called East Coast fever when discovered in some imported cattle introduced through Beira. A few years later, Lounsbury and Theiler (1905–7) repeated the transmission. They showed that nymphs of *R. appendiculatus* infected as larvae were also capable of carrying the disease. Next they tried other species of ticks and discovered that *Rhipicephalus capensis, Rhipicephalus evertsi, Rhipicephalus simus* and *Rhipicephalus nitens* (later shown to be *R. appendiculatus*) could also act as vectors of the disease.

Many years later here in East Africa, Fotheringham and Lewis (1937) incriminated some of the species of Hyalomma as E.C.F. carriers; in 1946, Lewis, Piercy and Wiley added *Rhipicephalus neavei* (now called *R. pravus*) to the list of possible vectors. Finally, Wilson (1952) added *Rhipicephalus kochi* and *Rhipicephalus ayrei* to this now formidable list.

If all these species of ticks were as efficient at carrying E.C.F. under field conditions as they are experimentally at laboratories there would be no "clean" areas in East Africa. In fact, however, the common brown tick appears to be the only E.C.F. vector of real importance under natural conditions. Undoubtedly, one of the reasons for this discrepancy is that the immature stages of some species other than *R. appendiculatus* prefer, as their hosts, rodents, hares and other animals incapable of infecting them with the parasite of E.C.F. It should be remembered that E.C.F. is never passed on through the tick's egg; hence "pepper" ticks (larvae) can never carry the disease.

Let us now turn to the ecological factors which appear to control the distribution of the species. Adequate rainfall is obviously of vital importance for its survival. In South Africa, Theiler, G. (1949), states that it can exist in areas with an annual rainfall of as little as 15–20 in. Here, in East Africa, the figure appears to be slightly higher and an average annual rainfall of at least 20–25 in. is necessary for survival of the ticks. Possibly greater solar radiation and rates of evaporation are the explanation for the higher rainfall requirement within the tropical belt.

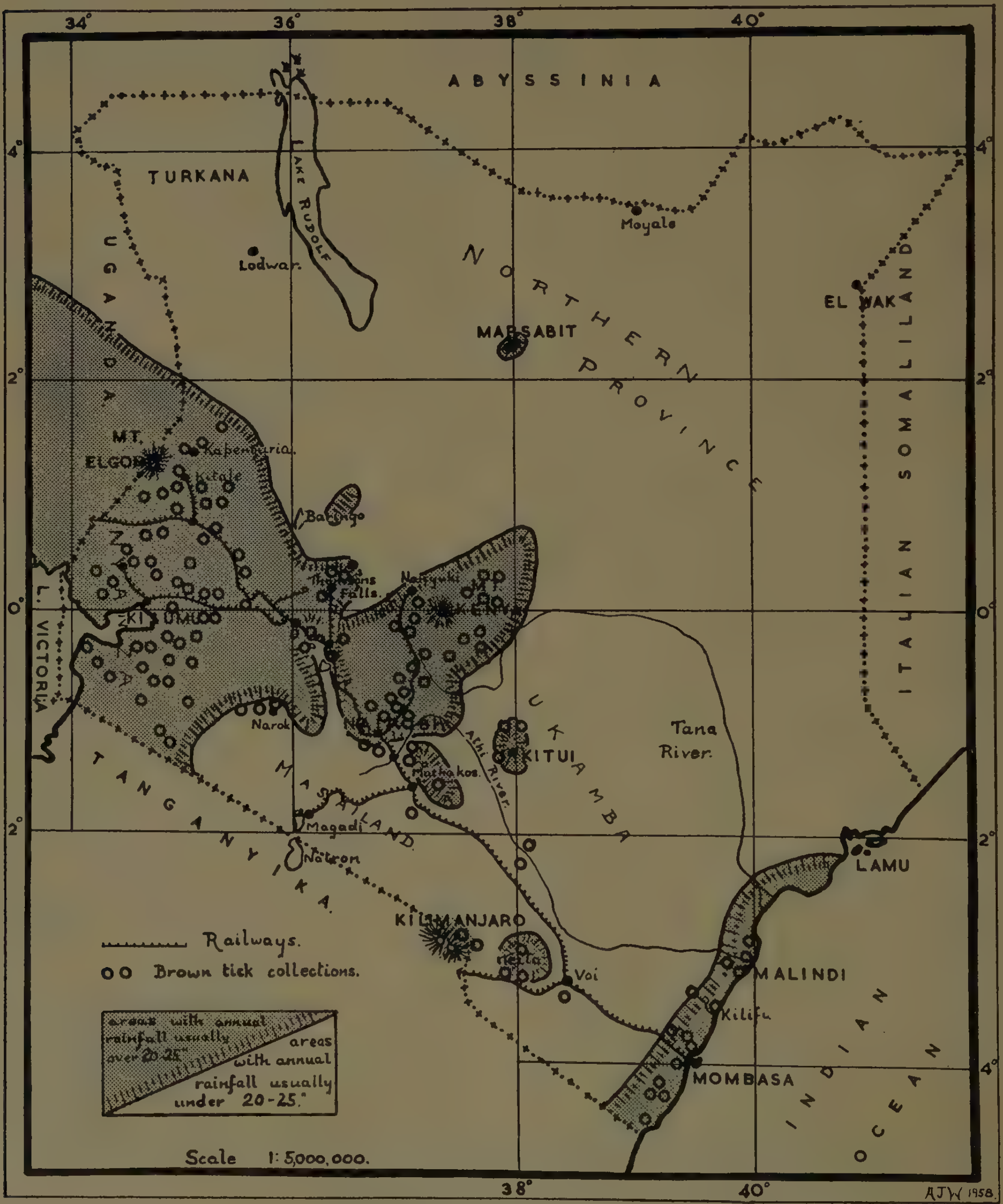
Altitude, or at any rate the climatic changes inevitably linked with it, plays its part in governing the distribution of the species which occurs from sea-level up to a height of approximately 7,500 ft. In the hinterland behind the coastal belt *R. appendiculatus* disappears owing to a combination of high temperature and low humidity. It occurs again at an altitude of about 4,500 ft. The optimum conditions within the highlands appear to be those pertaining between 4,800 ft. and 7,000 ft. As the altitude increases above 7,500 ft. the species rapidly disappears. It is probable that frost and a low mean minimum temperature are partly responsible for this. Laboratory experiments (Lewis, 1939) have shown that an engorged female brown tick is unlikely to tolerate exposure to cold temperatures of 0°–4° C. for more than 11 days. Below 6° C. she will not lay and will postpone doing so until returned to normal temperatures of about 20° C. The resulting batch of eggs is likely to be small with few larvae hatching from it.

Throughout its range in Kenya *R. appendiculatus* is frequently associated with *Amblyomma variegatum,* the carrier of heartwater. Both species avoid the arid parts of the country. The chief difference between the distribution of the two is that *A. variegatum* is capable of surviving at higher altitudes and has been collected at Timboroa and on the Cherangani range at altitudes too high for the survival of the brown tick.

During the past 25 years, inumerable ticks have been collected and sent to the Veterinary Laboratory at Kabete for identification. By gathering these records together and plotting them on to a map of the Colony we are able to derive a fairly accurate picture of the distribution of *R. appendiculatus.*

NYANZA PROVINCE

The species is common throughout the greater part of this province, it occurred in collections made at all of 36 villages visited in South Nyanza, 28 in Central and 53 in North Nyanza. Further to the east in the Songhor-Muhoroni area, it is also a common species in



Distribution of the brown tick in Kenya

those parts where efficient dipping has not abolished it. The weather in these western districts of Kenya lying south of Mount Elgon is affected by the proximity of Lake Victoria Nyanza. Here, with a supply of moisture always available, showers and thunderstorms are likely to occur at fairly regular intervals throughout the year. These conditions seem admirably suited to the requirements of the tick.

RIFT VALLEY PROVINCE

In both the Uasin Gishu and Trans Nzoia districts the species is again a common tick in those places where dipping has not eliminated it. Northwards in the Kapenguria area the species mingles with the very similar dry-country species *R. parvus*. *R. appendiculatus* occurs down to altitudes below 5,000 ft. at the foot of the escarpment on the Kitale–Lodwar road. It has been collected at Mitemburu and Kreswa in this area and it is to be found at Chepararia on the Kapenguria–Sigorr road. It occurs at Chepkorio at slightly over 8,000 ft., at Chemusuk, Kachamogen, Mbaara (Sekerr Location, altitude 6,150 ft.), Sebit (Batei location, altitude 4,900 ft.), Parua (Batei location, altitude 7,150 ft.), Moribus (Batei location, altitude 5,100 ft.), and at Ortum (Batei location, altitude 4,600 ft.).

The floor of the Great Rift Valley which divides the Colony in two, running from Lake Rudolf in the north, southwards to Lakes Magadi and Natron near the Tanganyika border, offers a suitable habitat to the E.C.F. tick only at its higher elevations in the settled areas. The tick is recorded from Nakuru, Elmenteita, Gilgil and Naivasha, but even in these districts its range is fairly limited. North from Solai and south from near Ngong the land becomes rapidly more arid and is quite unsuitable for the tick.

Further eastwards it occurs at Subukia on the edge of the escarpment and in the vicinity of the Karati forest above Naivasha. This latter place is one of the highest parts of the country at which *R. appendiculatus* and occasionally East Coast fever outbreaks occur. The altitude is 8,000 ft. or slightly over, but owing to the sheltered nature of the land and the absence of frost the tick appears to be able to survive. On the high plateau of the Kinangop the species is absent; the open nature of the ground with its frosts, wind and sun and occasional waterlogging, form a combination of factors with which *appendiculatus* is obviously unable to contend.

The species is to be found also to a limited extent at Thomson's Falls and in parts of the Rumuruti district. The writer also has records of it off buffalo shot at Thomson's Falls, Rumuruti and Ol Arabel. It is known that buffalo carry the brown tick, probably over large distances at times and it has also been proved that they are capable of infecting the ticks with the parasites of E.C.F. (Lewis, 1943).

CENTRAL PROVINCE

Generally speaking, the tick is absent from all the dry areas lying to the north of Mount Kenya and from the eastern districts of Meru and Embu. The species is common in most of the remaining parts of the province with the exception, of course, of land rising above about 7,500 ft. It occurs in the lower parts of Timau, at Nanyuki, Naro Moru, Ngobit, Mweiga and around Nyeri and Fort Hall. In the outlying districts of Nairobi such as Thika, Ruiru, Kiambu, Kabete and lower Limuru the tick is common; around Meru and Embu and the Nyambeni range it is also a dominant species.

SOUTHERN PROVINCE

Large areas of this province are free of the tick and consequently of East Coast fever.

In Masailand the brown tick is recorded from the western districts in the vicinity of the Mara River and in the Lemek valley. It occurs again between Athi River and the Kedong in the Ngong area, and again between Konza and Kima. During recent years it has been discovered in the Loitokitok district on the northern foothills of Kilimanjaro, an area which, before the last war, was free from it. The Masai blame the movement of stock from Tanganyika to the meat factory at Athi River during the war for its arrival in the area.

In the Ukamba country the stronghold of the brown tick is around Kitui and the neighbouring locations. Here the rainfall is higher than in the surrounding country, being just sufficient for the survival of the species. East from Kitui the land becomes rapidly drier and unsuitable but to the south "pockets" of the tick do occur, as it has been collected from Ikutha and from near Kibwezi. The collecting of the tick at these two places may well be connected with the movement of stock in abnormally wet seasons. These districts are far more the home of the very similar and closely related dry-country tick, *Rhipicephalus* *pravus*. The brown tick is also to be found in Machakos and some of the surrounding districts.

NORTHERN PROVINCE

Most of this part of the Colony is either desert or semi-desert with a very low annual rainfall and the brown tick, as far as is known at present, does not occur. The possibility of it eventually being discovered on some of the isolated forest-clad hills in Turkana and in places like Marsabit, however, should not be ruled out. Collections have not yet been made on most of these mountains.

COAST PROVINCE

The common brown tick is absent from the northern parts of this province. The Lamu hinterland and the Tana River districts are quite unsuited to it. The northern limit of its range along the Kenya coast is in the vicinity of Mto Pamamba a little north of Malindi. It occurs only a very few miles south of the Kirawa holding ground which is used by the stock being trekked southwards to the Mombasa markets; from this point onwards, these cattle are liable to pick up East Coast fever unless dipped. From Mambrui down to the Tanganyika border the brown tick occurs intermittently, being confined to the coastal strip and never extending inland more than 50 miles at the most.

Within this region the species has been collected from Mambrui, Malindi, Gongoni, Goshi, Bamba, at the Voi river north-west of Bamba, Mangea Hill near Vitengeni, Kaya Jorore, Kaloleni, Miritini, at Kwale and on the Shimba Hills.

In the lower rainfall areas inland behind this narrow 50-mile belt the tick is absent except on some of the higher hills. It is to be found on the Teita Hills, at Taveta, on Sagala Hill near Voi and may well be found to occur on Mount Kisagao also, though no collections have yet been made on the higher parts of this mountain.

SUMMARY

The importance of the common brown tick (*Rhipicephalus appendiculatus*) as a carrier of disease is discussed, with special reference to East Coast fever and the history of its role in this disease. The effects of climate and altitude upon the distribution of the species are also summarized.

The distribution of the tick within each of the provinces of the Colony is then given in detail.

Generally speaking the brown tick occurs throughout western Kenya, is common in those parts of the highlands below about 7,500 ft., especially where cultivation predominates and where dipping is not carried out. There are numerous "pockets" of *R. appendiculatus* in the southern parts of the coastal belt. The high plateau, the plains, the deserts and the dry bush areas are usually free of this tick.

ACKNOWLEDGMENTS

This paper is published by permission of the Director of Veterinary Services, Kenya. The author acknowledges with gratitude the help given over the past 20 years or so, by officers of the Veterinary Department, of the Game Department, by members of the farming community and all those who have collected and forwarded ticks to the laboratory at Kabete. Thanks must also be expressed to Miss J. B. Walker of the East African Veterinary Research Organization, for permitting the use of records of ticks collected and identified by her; and finally, to J. Glover and P. Robinson of the East African Agriculture and Forestry Research Organization on whose 20-in. probability rainfall map, the map included here is based.

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PALATABILITY OF MAIZE UNDER STORAGE IN UGANDA

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When well-conditioned maize is stored in the tropics and in particular in the wetter areas, it eventually becomes infested with insects. The rate of infestation will depend on the conditions of storage but even efficient storage methods can fail and serious insect pest outbreaks occur. Certain methods of insect control, the most important of which is that obtained by the addition of insecticides to the grain, can delay an infestation for a considerable period permitting long storage under relatively insect-free conditions [1]. However, less efficient treatment may only retard the rate of infestation, resulting, during the storage period, in a reduction of weight and quality of the grain. In previous work on stored products little attention has been given to the effect of an insect infestation on the palatability of the grain, especially when the presence of insects has not caused severe heating to the grain. The efficiency of storage treatments has invariably been judged by the final loss in weight or number of grains damaged. If, however, a maize producer is concerned with quality, particularly if he is to sell his product for human consumption, then the effect of storage, with or without an insect infestation, on the palatability of the maize is important and should not be overlooked.

Such a suggestion is further emphasized if encouragement is to be given to indigenous non-maize eaters to use maize, which is already an important cash crop in parts of Buganda, as an addition to their traditional basic diet. This is a point of considerable importance with the increasing populations, particularly in the urban areas, where the staple diet, bananas, cannot be stored or made so readily available as maize at all times of the year. It is from this aspect of palatability that the present work was initiated with special reference to Uganda maize and the local consumer.

EXPERIMENTAL METHODS

Stored maize of varying age and degrees of insect infestation was presented to a number of tasters for grading into levels of palatability. The maize which was either hammer-milled or roller-milled into meal, was, in all tests, presented as the raw and cooked product. When it was cooked the identical cooking procedure was followed for each sample, i.e. a weighed sample of flour was boiled for a set time in a measured quantity of water. The cooked preparation of each sample was presented as well as flour, as it was the opinion of the African tasters that any difference in palatability was more likely to be noticed in the cooked preparation than in the raw flour, but differences in appearance were more readily noticeable in the flour than in the cooked preparation. No other ingredients were added to either of the preparations. Each series of samples was then presented at random with the two preparations kept separate and run as distinct tests.

The tasters, chosen from the African Staffs of both Namulonge and Kawanda, were of various income levels and from different tribes. These were divided into two groups, the maize eaters, the immigrants from the maize eating areas, and the non-maize eaters, the Baganda and similar indigenous tribes. The division was shown later to be unnecessary, as little variation in the keeness of palate existed between them as compared with the individual tasters from each group. In fact it was surprising that some of the better individual tasters came from the non-maize eating group. The tasters were admitted one at a time into the room where the samples were displayed and asked to examine the samples in any way that they considered necessary, and to grade them as either good, fair or bad. (The scores given were 3, 2 and 1 respectively). The tasters adopted a uniform procedure, which was to look at the flour, pick some up in their hand, smell it and finally taste it. Identical procedure was followed when grading the cooked preparation.

The three-grade system used during the experiments was found to be the most workable method, as a more extensive system only confused the tasters. Similarly, the validity of palatability tests, using unskilled tasters, depends on the tasters noticing distinct differences between the samples. Such differences are best obtained by using as few grades as possible.

The results obtained from the following tests are presented as the mean grade for each of the two groups described and of all tribes together. Statistical analysis of the data was undertaken, but owing to the discrete nature of the grading system and the high variability between the tasters no further reliable qualification to the arithmetic presentation could be made.

Experiment 1

The first experiment was designed to determine the variability of quality between maize at various levels of insect infestation. Apart from the infestation, the maize used was in good condition, having been stored for seven months and not having exceeded a moisture percentage of 14 during this period.

The degrees of insect infestation in the samples of maize ranged, at 10 per cent intervals, from 10 to 50 per cent damaged grains, caused chiefly by *Calandra oryzae*. Maize with 50 per cent of the grains damaged was chosen as the maximum infestation that could be tolerated, since this in itself is considered to be a sufficient index of damage to reconsider prolonged storage. Two samples from each level of infestation were taken, one was sieved free of all insects and detritus, the other was left untouched. All the samples were then hammer-milled.

The results, illustrated in Fig. 1, show a close similarity between treatments, with the tasters having no distinctive dislike to the meal at any particular level of infestation. There is, however, a slightly lower grading of the more heavily infested samples, but this is probably too insignificant to be considered. On the other hand, the similarity between the cooked and uncooked samples in the sieved maize contrasts with the difference between the two preparations of unsieved maize. The lower grade given to the flour of the unsieved maize may have been based more on appearance than taste, as the insects and detritus, which progressively increased with the higher infestation, gave the flour a dirty appearance.

However, it is concluded that little or no difference in palatability was noticeable between samples of grain with varying degrees of insect infestation, up to 50 per cent damaged grains, whether sieved or unsieved or as cooked or uncooked flour. It is interesting to note that the general opinion of the tasters was that the maize meal tasted slightly stale due to storage. No failure of storage had occurred in the maize presented other than insect attack, it was also well conditioned prior to storage. Therefore the length of storage period was probably the main factor promoting the criticism. This observation led to the next experiment.

FIG. 1

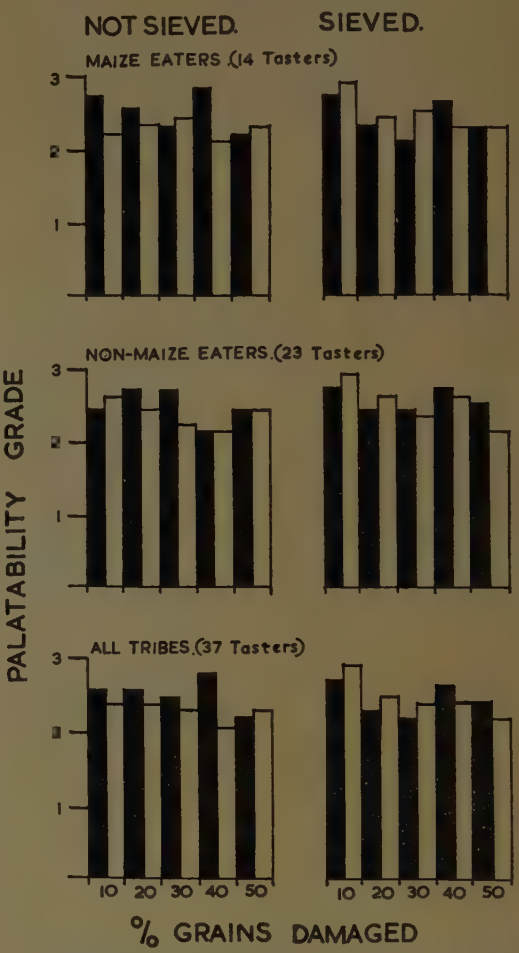


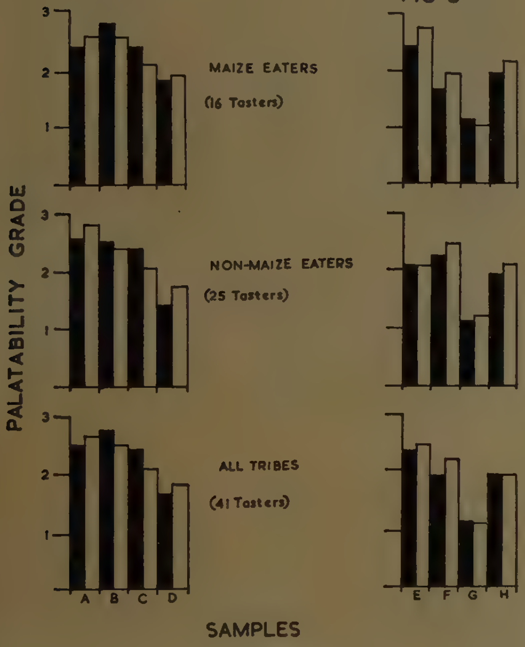
Fig. 1—Mean palatability grade (1 = bad, 2 = fair, 3 = good) of maize at various levels of insect infestation, presented as raw (hollow columns) and cooked (solid columns) meal.

Experiment 2

The difference between long-and short-termed stored maize was investigated along similar lines to the previous experiment. The maize however was relatively free from insects (less than 3 per cent damaged grains) and was in excellent condition. The maize was milled direct from storage and was not previously sieved. To make the experiment more comprehensive to get a better understanding of the preference of the local inhabitants, the samples were presented as flour produced by both roller* and hammer milling.

The results are illustrated in Fig. 2.

FIG 2 FIG 3



Figs. 2 and 3—Mean palatability grade (1 = bad, 2 = fair, 3 = good) given to samples of maize following various storage and processing treatments. The maize was presented as raw (hollow columns) and cooked (solid columns) meal or flour.

Samples:

Fig. 2
- **A 2 month-old maize, roller-milled.**
- **B 16 month-old maize, roller-milled.**
- **C 2 month-old maize, hammer-milled.**
- **D 16 month-old maize, hammer-milled.**

Fig. 3
- **E 6 week-old maize, hammer-milled.**
- **F 7 month-old maize, hammer-milled.**
- **G Locally milled Uganda Maize, hammer-milled.**
- **H Locally milled Kenya maize, hammer-milled.**

No difference was apparent between the 16 month-and two month-old maize that was roller-milled, both as the cooked and uncooked samples, but when the maize was hammer-milled, the meal from the two month-old maize was consistently given a higher grade than the meal from the older maize. However, the roller-milled uncooked flour was preferred by the majority of the tasters to the hammer-milled product, regardless of storage time. The preference was again probably due to the appearance, together with the texture of the roller-milled flour, than from the palatability alone, since the meal from the two month-old hammer-milled maize when cooked equalled the grade of the roller-milled samples. The older hammer-milled maize was readily distinguished from the two month-old maize, both as the meal and cooked samples, and was given a mean grade of between bad and fair compared with the two month-old sample of between fair and good.

EXPERIMENT 3

The final experiment was conducted to compare new maize with seven month-old maize (intermediate storage period); both were well-conditioned and free from insect infestation, and maize meal was locally milled from Uganda and Kenya maize. Unfortunately the age and condition of the locally purchased products were not known, but from an incubated sample of the Uganda flour, which was visibly insect free but dirty and very brown in colour, a large number of insects emerged comprising *Tribolium casteneum* and *Ephestia cautella*. All samples were hammer-milled.

The preference for the well-conditioned maize of both ages was greater than for either of the locally milled products, with the Uganda maize flour consistently given the lowest grade (Fig. 3). The seven month-old well-conditioned maize was on this occasion given a lower grade of palatability by the maize-eating group of tasters, but was considered equal in quality by the non-maize-eating group. The flour milled from Kenya maize was graded equally with the older well-conditioned maize.

DISCUSSION

If maize is to be considered in Uganda as a major part of the diet of the people it is important that investigation into storage principles should take into account the quality of the final product sold to the local consumer.

From the data presented it can be argued that since little or no distinction could be made between maize with various levels of insect infestation, in this case up to 50 per cent damaged grains, then possibly the tasters used were not of sufficient sensitivity of palate to be the judges of maize quality, when presented to them as raw or uncooked flour. However, it was commonly remarked by the tasters that it was not the presence of insects in this case which lowered the quality of the flour but the characteristic flavour of long storage. It is therefore suggested that grain deterioration after long storage is a major factor contributing to poor palatability over and above insect infestation, providing the infestation is not severe and does not cause secondary deterioration of the grain. The tasters also believed that grains showing partial germination, or discolouration due to fungal attack, were also causal agents to poor palatability.

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*Low extraction rate (60%) roller-milled flour was used containing practically pure endosperm.

With further tests it was confirmed that a distinction between old and new maize could be made, when all other factors were equal i.e. in this case no apparent insect infestation or other factors arising from bad storage. However, if the maize was presented as roller-milled flour the distinction could not be made as readily as with the maize that was hammer-milled. Maize that has been stored for a considerable period becomes "more acidic partly as a result of hydrolysis and oxidation of the fats giving rise to fatty acids and partly as a result of changes in the mineral constituents". [2]

Therefore with the hammer-milled samples where no part of the maize grain is extracted from the final product, acidity would obviously be higher than in roller-milled flour, due to the presence of the germ which contains a large proportion of the fats and oils contained in the seed. From the aspect of palatability the results would suggest that if it is necessary to store maize over a long period, then the final product is best supplied for human consumption as the roller-milled flour described. From the nutritive point of view, however, such a suggestion may be questioned.

There is no doubt that from the data considered as a whole, the local Africans who were chosen as tasters were quick to judge the good from the not-so-good and bad maize flour which in most cases was entirely due to the age of the maize, even if it had been stored under ideal conditions. The comparison between estate-grown maize, well-conditioned before storage, was given a high grade in comparison to the maize flour grown and milled locally, suffering from obvious results of poor conditioning and storage.

The points that should be emphasised with view to maize storage and its eventual consumption by the local inhabitants, under the present conditions in Uganda are:—

(1) The maize must be well-conditioned prior to storage i.e. dried to a suitable moisture content.

(2) It must be protected from insect attack.

(3) It must be sold in the most palatable form to the consumer if it is to compete with traditional carbohydrate diet.

ACKNOWLEDGMENTS

We wish to express our thanks to Mr. H. G. Farbrother for his help and interest during the course of the work. Thanks are also due to Mr. H. L. Manning and Mr. J. Bowden for reading and criticizing the manuscript.

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A PRELIMINARY REPORT ON DEEP WATER FISHING OFF THE NORTH KENYA COAST

By F. Williams, East African Marine Fisheries Research Organization, Zanzibar

(*Received for publication on 27th March, 1958*)

The attention of this organization was first drawn to the possibility of bottom-fish in quantity in deep water off the North Kenya Coast, as a result of a cruise to the area made by the Provincial Fish Warden (Coast), Mr. T. E. Allfree, in the *m.v. Menika* during March, 1956. On the 24th and 25th of that month 160 fishes, mainly Changus (Lethrinidae), Snappers (Lutianidae) and Sali-Sali (Pristipomoides spp.), weighing 1,862 lb. were caught in water of 46–65 fathoms.

The first cruise (No. 95) to follow up this information was made by *m.v. Research* (of this organization) in mid-April, 1956, and a note on its results was published elsewhere (Williams 1956). Subsequently, three further cruises, Nos. 99, 104 and 112, were made to the area in August and November, 1956 and March, 1957. The preliminary work of these four cruises was designed:— (i) to establish the species of fish caught in deep water; (ii) to obtain an idea of the catch rate; (iii) to establish the depth at which the fish are found, and (iv) if possible, to see if fish could be caught in all weather conditions. The detailed investigations of this deep water fishery off the North Kenya Coast is being carried out by my colleague, Dr. J. F. C. Morgans and commenced in September, 1957.

The area of operations covered by the four cruises, from 2° 10′ S. to 2° 40′ S. and the positions of all fishing stations are shown at Fig. 1.

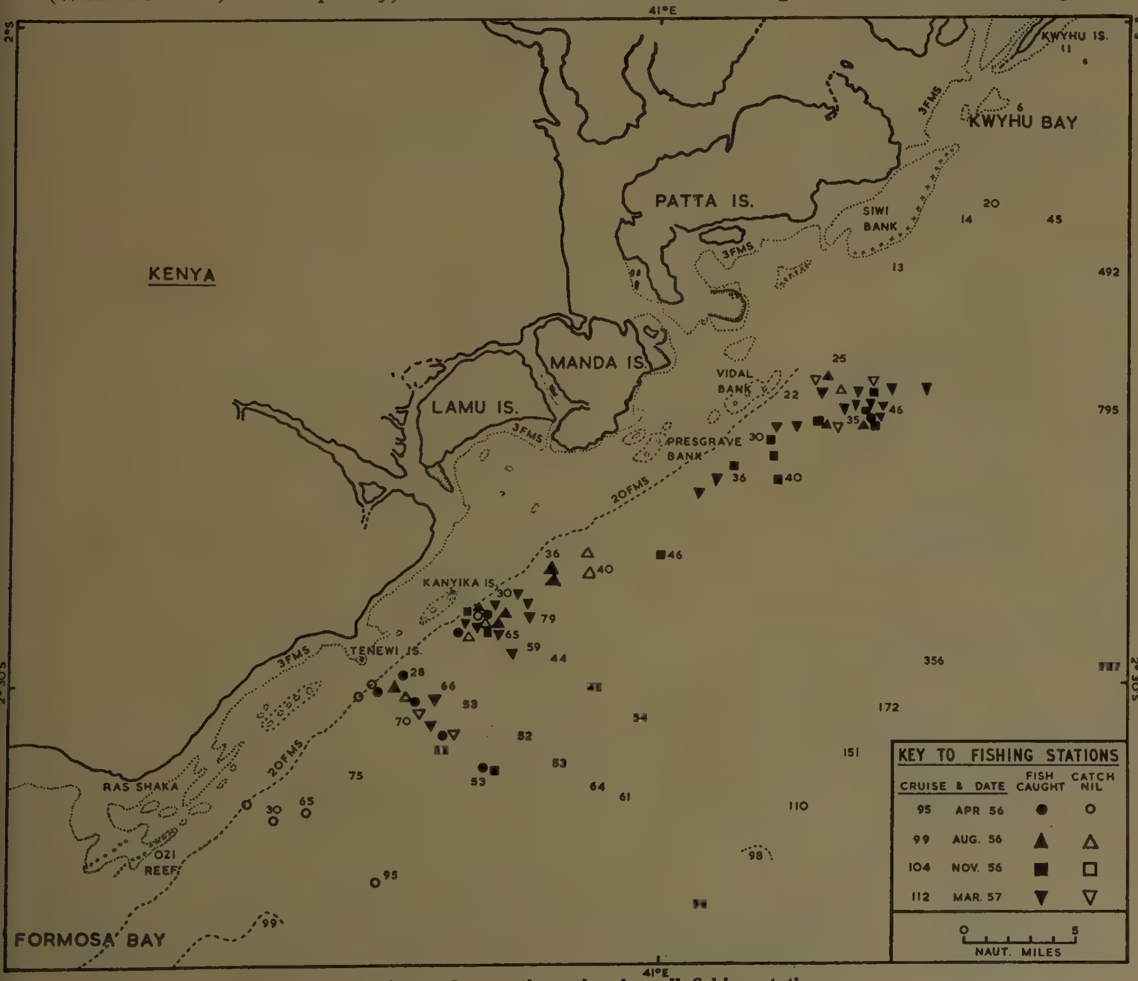

Fig. 1. Area of operations showing all fishing stations

Stations where fish were caught are differentiated from those where the catch was nil. It must be mentioned that the existing charts of the North Kenya area are quite inadequate for fisheries purposes.

At all times heavy barked cotton handlines with 2–3 hooks (Mustad 3 and 4) on short galvanized wire traces were used from *Research*.

During the period 32 species of fish and shark (all valuable food fishes) were taken in depths ranging from 18–79 fathoms, with the majority from 25–50 fathoms. The detailed list of species is given in Table I.

TABLE I

LUTIANIDAE:

- *Lutianus bohar**
- *L. rivulatus**
- *L. sanguineus**
- *L. sebae*
- *Aprion virescens*†

LETHRINIDAE:

- *Lethrinus caeruleus*
- *L. kallopterus**
- *L. mahsena*
- *L. microdon*
- *L. miniatus*
- *L. nebulosus*
- *L. waigiensis**

SERRANIDAE:

- *Epinephelus areolatus*
- *E. chlorostigma*
- *E. flavocaeruleus*
- *E. grammatophorus*
- *E. leprosus*
- *E. longispinis*
- *E. malabaricus*
- *E. tauvina*
- *E. undulosus**
- *Epinephelus* spp.
- *Cephalopholis sonnerati*
- *Variola louti*

MISCELLANEOUS:

- *Cheimerius nufar*
- *Scomberomorous commerson*†
- *Sufflamen capistratus*†

SHARKS:

- *Carcharinus albimarginatus*†
- *Ch. bleekeri*†
- *Ch. limbatus*†
- *Carcharinus* sp.†
- *Scoliodon* sp.†

*Most important species.

†Pelagic or midwater species.

The total catch was 573 fish and sharks weighing 5,676 lb.

The breakdown of the catch by weight is given in Table II.

TABLE II

	Wt. in lb.	% of total Wt.	Most important species and % of total weight	
Lutianidae ..	3,051	53·7	*L. bohar*	23·2
			L. microdon	19·4
			L. sanguineus	8·2
			Others	2·9
Lethrinidae ..	829	14·6	*L. waigiensis*	7·5
			L. kallopterus	4·8
			Others	2·3
Serranidae ..	1,467	25·8	*E. undulosus*	8·3
			Others	17·5
Miscellaneous	47	0·8		
Sharks ..	282	4·9		
	5,676			

The catch rates for the cruises of *Research* have been calculated and are listed in Table III. They are based on actual fishing time and take no account of time spent steaming to and from the grounds, moving station, etc.

TABLE III

Cruise No.	Date	Catch rate in lb./line/hour
95	April, 1956	13·0
99	August, 1956	15·3
104	November, 1956	24·0
112	March, 1957	22·4
	Overall average	18·7

For a vessel working out of Lamu, 7–8 hours per day could be spent fishing, depending on the distance of the fishing ground from Lamu. 6–7 lines fishing as from *Research* would give about 800 to 1,000 lb. of fish per day. It must be borne in mind, however, that experimental fishing of this type invariably gives a low catch rate, as heavy catches were often foregone so as to allow investigation of other unknown areas. The low catch rates of April and August compared with those of November and March are almost certainly due to the fact that (i) the April cruise was the first on deep water fishing in that area and (ii) that the August cruise was hampered by heavy seas and high wind, but it did prove that the fish were obtainable during the South East monsoon, at least in the month of August.

The overall catch rate for the Kenya Fisheries *Menika* was 28 lb./reel/hour (3–5 reels fished) for the period 17th March, 1956 to 6th January, 1957. This rate is based on the figures given at Appendix C of the Report on Kenya Fisheries, 1956. It must be pointed out that the figures are for fish caught in 32–55 fathoms, at stations between 1° 50′ S. to 2° 40′ S., a more northerly extension of the area than that fished by *Research*.

Comparison of cotton handlines with the nylon line and wire mounted on deep sea reels in *Menika* was made on one day during Cruise 104 and showed that, at least up to depths of 50 fathoms (i) the catch rate was similar to that of *Research* (ii) the species of fish and shark caught were the same and in about the same proportions, and (iii) the physical effect on the crew was similar. The use of a detachable hook and sinker section of the reels of *Menika* greatly decreased the time taken in removing fish and re-baiting. In depths greater than 50 fathoms the deep sea reels were certainly more efficient that the ordinary cotton handline. The use of wire is advantageous at all depths in areas such as this when there is a strong northerly current and set i.e. during the south east monsoon.

Bait did not prove a problem as pelagic fishes taken trolling on passage to and from the grounds and many of the smaller Serranids, such as *E. grammatophorus*, were sufficient to meet the requirements.

The report made here, supplemented by those made earlier (Williams 1956; Report on Kenya Fisheries 1956), is preliminary but the work both biological and technological does suggest the great potentialities of this area. However, the full evaluation of the fishery is dependant on the main investigations now in progress.

ACKNOWLEDGMENTS

For help with identifications my thanks are due to Dr. J. F. G. Wheeler (Sharks and Lethrinidae), Mr. F. H. Talbot (Lutianidae) and Dr. J. F. C. Morgans (Serranidae).

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GRASSLAND TRIALS AT TARIME LAKE PROVINCE, TANGANYIKA

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The grazing quality of the North Mara Highland grasslands appears to have suffered extensive deterioration due to uncontrolled grazing, and uncontrolled burning over a period of time. Coarse, wiry, tufted grasses such as *Pennisetum catabasis, Aristida adoensis* and *Sporobolus indicus* became dominant, especially *Pennisetum catabasis,* which occurs in great abundance over wide areas in this district.

In 1945, a policy of closely controlled rotational grazing, and a system of ley farming to eliminate the tufted grasses by cultivation and control of grazing to avoid rapid reversion to the undesirable tufted species, was advised. In 1949 it was decided to to begin a series of trials with a number of different treatments to study methods to control *Pennisetum catabasis,* and plots were laid down in 1951 with the object of finding out which treatments were likely to check its development and encourage the growth of more palatable species.

The rainfall in this region is good and the soil is fairly deep and fertile in the areas where this grass is dominant. It seemed therefore desirable also to include certain cropping trials followed by fallow. The local inhabitants produce reasonably good crops in this area, but they find it difficult to eradicate the coarse grasses with their hoes and small ploughs. Grass-burning and cutting treatments were planned in combination with controlled grazing, while the treatments were also to include continuous grazing as well as complete protection against fire and grazing.

Permission was granted by the chief and his elders for the use over a ten-year period of approximately 12½ acres situated in typical dense *Pennisetum catabasis* grassland, selected in the Busweta area, just south of Tarime, on the eastern side of the Tarime–Kinesi road.

In this area *Pennisetum catabasis* was dominant throughout with coarse, tall growth, and *Aristida adoensis, Sporobolus indicus* and *Loudetia kaggerensis,* all of which are species of wiry, coarse grasses, occurred occasionally. The more palatable species present included *Brachiaria brizantha, Brachiaria dictyoneura, Themeda triandra, Bothriochloa insculpta, Paspalum commersonii, Setaria sphacelata* and *Hyparrhenia filipendula.* These were all very closely grazed. A certain amount of herbaceous weed growth and woody species also occurred, particularly around large termitaria.

TREATMENTS

The treatments planned were as listed below and were all duplicated, except in the cases of the control and continuously grazed plots which were long, narrow plots, running throughout the whole series.

(*a*) *Control.*—Complete protection from burning, grazing and cultivation.

(*b*) *Burning in September.*—Protected from grazing between April and June. Grazed fairly heavily and intermittently during the early rains while the grass shoots are young and palatable.

(*c*) *Cutting of grass at the end of March.*—Protected from grazing between April and June and grazed fairly heavily and intermittently during the early rains.

(*d*) *Three year's cultivation, alternating with three years' fallow.* Judicious grazing after harvesting of crops and the fallows to be grazed on the same basis as outlined for the plots above.

(*e*) *One year's cultivation, alternating with one year's fallow.*—Judicious grazing on the same basis as outlined above.

(*f*) *Continuous heavy grazing.*

RESULTS

By 1953, the cutting and burning treatments did not appear to be meeting with much success, while burning also proved difficult. It was therefore decided that the main emphasis of the experiment should be shifted towards suppression of *Pennisetum catabasis* through cultivation. In similar country in the Kenya Highlands it had been shown that cutting and burning treatments were successful against such coarse tussock grasses as *Pennisetum schimperi,* while burning favoured an increase of *Themeda triandra* (red oat grass). Other work in Kenya showed that supression of *Pennisetum schimperi* takes place when a fierce fire occurs, while *Themeda triandra* is favoured by such treatment, and in some parts of the trans Mara area the grass-burning practices of the Masai favoured *Themeda triandra* at the expense of *Pennisetum catabasis* (Edwards, 1949).

It was observed in September, 1953, that early rains and lack of suitable combustible material sometimes made burning in September impossible. It seemed that burning just after the first rains in August might be more suitable. The cutting treatments also could not be carried out regularly due to management difficulties while it appeared that this treatment would have no practical application under existing farming conditions in North Mara. No definite conclusion could, therefore, be drawn from the effect of regular cutting on this tussock grassland type.

The plot subjected to continuous grazing was very similar to the typical grazing areas in the Tarime Highlands, consisting of the usual large tussocks of fibrous unpalatable *Pennisetum catabasis.*

In the control plot, which received protection against grazing, fire and cultivation, *Pennisetum catabasis* appeared to lack in vigour due to accumulated dry material which prevented its normal vigorous growth, and it seemed that other grass species were becoming more prominent.

The plots were inspected again during July, 1956, and it was confirmed that eradication of *Pennisetum catabasis* seemed successful only when it was completely removed by either plough or hoe. In the trial plots as well as in grass fallows in various parts of the Tarime Highlands it had been observed that re-invasion of *Pennisetum catabasis* was very slight after cultivation. The grasses which came in with cultivation are generally palatable species, but their carrying capacity seemed low under existing conditions. It seemed evident that a system of ley farming is required with the introduction of more productive pasture grasses such as *Chloris gayana.*

It was considered that by 1956 the experiments indicated that the coarse tufted grasses could not readily be eliminated by cutting or burning, and that neither is it readily killed by other grasses which come in. Cropping every second year or three years' cropping followed by three years' fallow prevented the undesirable tussock grasses from becoming established. Final observations were taken in August, 1957, and the condition of the plots could be briefly described as follows:—

(*a*) *Control.*—This plot supported a tall unruly stand of *Pennisetum catabasis, Hyparrhenia rufa, Themeda triandra, Setaria* sp. as well as local patches of *Imperata cylindrica,* and other grasses. Very little *Digitaria scalarum* was noticeable and where it did occur its growth was very thin and spindly due to severe competition with the tall grasses. There was a large amount of dry material that seemed to have a stifling effect on young growth. There also appeared to be a considerable increase and thickening of bush growth and herbaceous weeds which included *Ziziphus mucronata, Harrisonia abyssinica, Solanum panduraeforme, Acacia seyal, Gymnosporia, Rhus, Ficus, Povonia, Ocimum* and *Triumfetta* spp. From a grazing point of view the herbage was in a most undesirable condition and the only apparent advantage gained from total protection appeared to be the suppression of *Digitaria scalarum* (couch grass).

(*b*) *Continuous Grazing.*—A tall, very robust and coarse growth of *Pennisetum catabasis* dominated this plot, rather resembling areas without grazing control. Again, from the pasture point of view it was most undesirable, but, as in the case of the control plot, it had the effect of stifling *Digitaria scalarum* and only a few spindly and-poorly-developed plants of this grass were evident. There was comparatively little bush growth and weeds were not as prominent as in the control plot. Neither was there much evidence of other grasses, except for a small amount of *Hyparrhenia rufa.*

(*c*) *Burning in September.*—Difficulty was sometimes experienced in obtaining a clean burn due to early rains and rapid growth of green grass that was not readily inflammable. This plot rather assumed the appearance of the one that was subjected to continuous grazing. It would appear that this treatment would have little effect in actual pasture improvement in the area, although, no doubt, burning can be used advantageously in grazing management practices. It is inevitably included as one of the measures in local practice, where fires occur in different parts of the district from time to time in the normal course of events and the stock do graze the young grass shoots during early growth. These plots were ploughed in 1957 and the coarse grass was turned under, and in the subsequent growth there was comparatively little *Digitaria scalarum* present and some *Sporobolus indicus* occurred. A certain amount of weed growth was noticeable, particularly around termitaria, and the species included *Withania somnifera, Solanum panduraeforme, Vernonia glabra, Ocimum* and *Erigeron canadense.*

(*d*) *Cutting in March.*—Regular execution of this treatment proved difficult and it was considered that it would have very little practical application in the field under existing farming practices in North Mara. A dominant stand of *Pennisetum catabasis* was produced throughout, although cutting did provide more palatable herbage for the stock. These plots were also ploughed in 1957 and are now in a similar condition to those described in the previous paragraph.

(*e*) *Three years' cultivation, followed by three years' fallow.*—These plots at the end of their three years' fallow period supported an excellent cover of palatable indigenous pasture grasses and some legumes. The species included *Cynodon plectostachyus, Paspalum commersonii, Setaria sphacelata, Brachiaria brizantha, Brachiaria dictyoneura, Hyparrhenia rufa, Digitaria scalarum, Rhynchosia* sp. and *Trifolium* sp. There were very few plants of *Pennisetum catabasis* and *Sporobolus indicus,* while a certain amount of weeds were noticeable although mainly situated around termitaria. These included *Solanum panduraeforme, Withania somnifera, Erigeron canadense, Povonia* and *Ocimum.* From a grazing point of view, this has been a most satisfactory treatment, and is also one which could lend itself to further measures of pasture improvement, for example with the establishment of species such as Rhodes grass at the end of the cultivation period to produce a mixed Rhodes grass pasture instead of a natural "tumbledown" fallow. A tall-growing species such as Rhodes grass is not only likely to produce more fodder and grazing but would also mitigate against the spread of couch grass, thus simplifying matters during the succeeding cropping cycle, and facilitating the introduction of a more sound and more productive form of mixed farming. It seems that when land is left, fallow compaction of the soil over a period of time forces the couch grass rhizomes to the surface layers of the soil and shallow ploughing would seem advantageous to eradicate the couch grass at this stage, whereas deep ploughing only replants the rhizomes in a deeper layer of soft soil thus aiding couch grass in its development. It is proposed that further investigations should be pursued in North Mara to study the behaviour of couch grass under a system of mixed farming.

(*f*) *One year's cultivation, alternating with one year fallow.*—These plots also supported an excellent cover of indigenous palatable pasture grasses, and with regard to species and conditions, are very similar to those described in the previous paragraph, while, in general, the comments would be the same.

CONCLUSIONS

It would seem that a system of alternative husbandry and mixed farming would be the most desirable way of solving the problem of controlling coarse, fibrous tussock grasses in North Mara. Although the presence of this grass makes cultivation by hand and small implements difficult it nevertheless has the advantage of eliminating couch grass to a large extent by competition. Furthermore. *Pennisetum catabasis* does not seem to reinvade cultivated land, so that once it has been eradicated the land could be put to more productive use, provided that couch grass and other undesirable species could be kept under control. To achieve this end it might be found advantageous to introduce a system of ley farming and to establish tall-growing pasture species such as Rhodes grass before couch grass takes over grazing lands.

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PROTEIN CONTENT OF SUBSISTENCE CROPS IN UGANDA

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This study was first undertaken in 1952 in connexion with the work of Trowell, Davies and Dean (1954) on Kwashiorkor, a disease of children caused by lack of protein in the transitional diet after weaning. These authors concluded that no immediate solution to the problem was offered by supplements of animal protein, or by purchases of commodities like dried milk, because they could not be produced in sufficient quantity in the near future. They suggested that a survey of crops contributing to the normal home diet would be instructive.

METHOD

Acreages of all the principal crops planted are published in the annual reports of the Department of Agriculture by districts. They are compiled by the simple enumeration of all fields planted and by pacing sample fields for mean field size. No claim is made for their accuracy, but the size of a putative acre is immaterial in a comparative study provided that it is reasonably consistent. Acreages reported for the years 1951 and 1956 have been used as the basis for this paper. Thirteen agricultural districts are considered, omitting the pastoral district of Karamoja.

The size of the total harvest is estimated by applying the raising factors in Table I for yield per acre. These factors are founded on the best local opinion, and the records of departmental farms, but are otherwise arbitrary. They are conservative and are intended to make allowance for such hazards as loss in storage. The F.A.O. List No. refers to Chatfield (1954) and serves to identify the form in which each crop is considered. In general crude forms have been chosen to make due allowance for water content and processing. Maize in the home is considered as a vegetable and not as a cereal, as this view is the more realistic.

TABLE I—CROP YIELDS IN TONS/ACRE

F.A.O. List No. and Crop	Buganda, Bunyoro, Toro, Busoga, Mbale	Ankole, Kigezi	Teso, Lango	Acholi, West Nile
1 Wheat ..	1/3	1/3	—	—
11 Rice ..	1/3	—	1/3	1/3
26 Sorghum ..	1/3	1/3	1/3	1/3
27 Finger Millet ..	1/3	1/3	1/3	1/3
34 Potato ..	1/3	1/3	—	—
36 Sweet Potato ..	3	2	2	2
37 Cassava ..	3	2	3	2
52 Groundnuts	1/4	1/4	1/4	1/4
54 Soya ..	1/3*	1/5	—	—
63b Beans ..	1/5	1/5	1/6	1/6
63i Cowpeas	—	—	1/6	—
63k Peas ..	1/5	1/5	—	—
63l Pigeon Peas ..	1/5	—	1/5	1/5
71 Sesame ..	1/7	1/7	1/7	1/7
113 Maize ..	1/3	1/3	1/4	1/4
118 Plantains	3	3	2	—

*1/5 in Toro.

Sales to commerce have been subtracted from the total harvest to give the remainder available for consumption in the home. These sales are published in the annual report of the Department of Agriculture for 1951, but are not published for 1956.

The remainder is then considered as "retail weight" in the sense of Chatfield's Table I, this being the form in which the produce would normally change hands if a sale took place. Each entry is raised firstly to numbers of calories and secondly to grammes of protein, using the appropriate factors from Chatfield's Table I. From the sums of these quantities for all crops a quotient is obtained for grammes of protein per 100 calories in each district and year.

RESULTS

The quotients obtained by this method are set out in Table II.

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TABLE II—GRAMMES PROTEIN PER 100 CALORIES

	1951	1956
NORTHERN PROVINCE:		
West Nile	2·18	1·89
Acholi	2·60	2·64
Lango	2·80	2·76
EASTERN PROVINCE:		
Teso	2·41	2·21
Mbale	1·68	1·62
Busoga	1·57	1·32
WESTERN PROVINCE:		
Bunyoro	1·48	1·26
Toro	1·33	1·44
Ankole	1·78	1·35
Kigezi	2·45	2·12
BUGANDA KINGDOM:		
Mengo	1·43	1·73
Masaka	1·24	1·63
Mubende	1·22	1·92

The method is not intended to be used for the estimation of absolute amounts, but as a rough check the numbers of calories available per head per day have been calculated, using the agricultural statistics for 1951 and the populations obtained in the 1948 census (as reported by the Department of Agriculture in 1956). This gives a mean figure of 4,374 calories per head per day, which is too high, but which is of the right order of magnitude. One likely reason for this over-estimate is that the produce of fields set aside as a reserve against famine is not regularly consumed.

DISCUSSION

The method takes no account of animal products or pot herbs and most people will have a slightly better diet than Table II suggests. It is the purpose of this paper, however, to consider the characteristics of the basic diet.

Trowell (1957) has rated Kwashiorkor as "uncommon" in the Northern Province of Uganda, and as "common" in Buganda, Eastern Province and parts of Western Province. The evidence of Table II is fully concordant with this assessment. Brock and Autret (1952) state that a diet with less than 2 g. protein per 100 calories must lead almost inevitably to protein deficiency. The values below 2 in Table II are confined to districts where plantains constitute the staple food, with the single exception of West Nile in 1956, where cassava is extensively grown. It is therefore instructive to examine agricultural practice in the different parts of Uganda to see what influences the value of the figures obtained in Table II.

Northern Province.—The people are of Nilo-Hamitic stock and, particularly in Lango district, they have an ingenious system of growing first finger millet and then sesame under a light canopy of pigeon peas. Table II shows that they have the best diet of vegetable protein anywhere in Uganda. The cultivation of sweet potatoes and cassava as a reserve against famine is out of character to the Lango and Acholi people, and although this reserve may be necessary, it is to be hoped that they will not neglect their traditional system. Cassava is grown and consumed in West Nile district because the crop is familiar in the neighbouring countries of the Belgian Congo and Sudan, with which the people have affinity. Consequently the figures for West Nile in Table II are somewhat lower.

Eastern Province.—The Teso people are of Hamitic stock and their traditional staple food is finger millet. This, supplemented by groundnuts and cowpeas, gives reasonably satisfactory figures in Table II. But the elimination of mosaic disease from the cassava crop has led to a considerable increase in its cultivation, because it is coming to be regarded as a cheap and easy source of food and not merely as a reserve against famine. This explains the lower figure for 1956 in Table II.

In Mbale (now Bugisu and Bukedi) and Busoga districts the people are mainly of Bantu stock and plantains are grown, supplemented by finger millet. Groundnuts and beans are important sources of protein, but in Busoga the acreages of these crops have been declining, which accounts for the low figure for 1956 in Table II.

Western Province.—The people are of Bantu stock (excluding the pastoralists) and the staple food in Bunyoro, Toro and Ankole is plantains, supplemented by finger millet in marginal areas. In Bunyoro there is a tendency to grow more sweet potatoes and less finger millet. Part of Ankole is pastoral, but elsewhere there has been a large increase in the acreage of plantains. In both districts there is a drift to a lower figure in Table II.

The high elevation of most of Kigezi district restricts the cultivation of plantains. Sorghum, finger millet, peas and beans are grown on the hillsides and sweet potatoes in the swamps. Despite a dense population, the nutritional status of the people is believed to be good and the protein-calorie ratio revealed by the present study supports this belief. But the tendency to extend the cultivation of sweet potatoes in swamps is having an adverse effect, which explains the much lower figure for 1956 in Table II.

Buganda Kingdom.—The people are of Bantu stock and the traditional staple food is plantains. The improvement over the five-year period in Table II is explained by increases in the acreages of groundnuts and beans and by a reduction in the acreage of cassava. The fact that the worst clinical and dietetic situation was found originally in the most developed and prosperous area provoked comment in medical and agricultural circles and received some publicity. There is reason to believe that the improvement noted is a genuine response to the educational efforts which have been made in the light of this knowledge. If so similar efforts in other areas might achieve a useful improvement in diet quite quickly.

CONCLUSION

There is no doubt that the work of the Department of Agriculture has done much to reduce the risk of famine. But the widespread cultivation of sweet potatoes and cassava as a reserve against famine and the reduction of the disease factor in the cassava crop have undoubtedly tended to popularize these foods, as they are both cheap and easy to grow. The time has now arrived to temper this policy with moderation and to guard against a progressive deterioration in nutritive balance. Although the method adopted in this paper is admittedly crude it can be applied easily and to some effect.

SUMMARY

This study was undertaken in connexion with the work of Trowell, Davies and Dean on Kwashiorkor. It is an attempt to estimate the protein-calorie ratio of the home diet from agricultural statistics.

Although the methods is crude the results are fully concordant with the picture presented by clinical survey. The public is ignorant of the facts in most districts, and education might achieve a useful improvement in diet quite quickly.

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SUBSISTENCE AGRICULTURE ON THE TANGANYIKA COAST

(*An analysis of some reasons for the failure of smallholding agriculture in Pangani District, Tanga Province.*)

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During a two-year study of the subsistence agriculture of three sample villages, a high proportion of failures to reach a satisfactory harvest were discovered. Both the people themselves and Government instructors tended to attribute these failures to acts of God and laziness, but a close examination of a number of cases showed that these were used as excuses and did not disclose the real reasons of which the cultivators themselves may not have been aware.

The real causes of the failure were a wide variety of potentially avoidable economic, social and magico-religious, and other reasons of which it is proposed to examine a few from actual examples.

A statistical analysis of these factors was found to be impossible owing to the length of time taken to discover, examine and discuss individual cases as well as because of the difficulty of analysing multiple causes.

In a final section the failure of a small agricultural scheme is analysed to show how a theoretical sound smallholding scheme collapsed because of a multitude of factors outside the scope of its original agricultural planning.

MEDICAL AND DEMOGRAPHIC REASONS

A different balance between the sexes may be suitable for different ecological conditions, as a preponderance of women may be an advantage in light bush where there is little clearing to be done before planting but not when riverine thicket has to be hacked down.

Juma was an Mgindo with four wives but no adult sons who moved from an area of light bush into riverine forest; although he worked extremely hard, he was unable to clear four separate fields of adequate size for his wives, as required customary law, with the result that throughout the cultivating season his wives were not fully employed and their harvest was inadequate for their needs. If he had reduced his establishment before the move, he would have done well in this new locality.

The house site may be chosen with a view to its agricultural potentialities but ignoring health considerations.

Abdallah found some good valley land and went to live there near to his new fields. The site was low-lying and waterlogged in the wet season, as well as being cut off from any breeze by thick forest and low hills, with the result that the health of his family suffered and field-work could not be done properly. If he had built on rising ground two hundred yards away they would have been largely free of mud and mosquitoes.

A move to a new locality in which there are no friends or relatives, and without adequate reserves of food or money, may mean a poor harvest resulting in malnutrition, which continues the cycle of poor returns.

Muhando and his family had had a poor harvest for their first year in a new locality so that in the coming season when they should have been clearing their fields both he and his wives were visibly sufferng from a poor diet, and one child actually died of starvation after suffering for some time from hunger oedema. If he had cut his losses after the first poor harvest and returned to his relatives he would have been able to have started again later, but now it will be several years before he can hope to do well.

The work potential of a family group is related to the size of their cultivation, and this may be very narrowly balanced, so that if one person in the group is not able to do his full share of work, or their work capacity as a whole has been overestimated, the whole family will suffer in the reduction of their harvest.

Kasulu and his wife cultivated together, but during the working season their daughter came home to have her first baby under her mother's care, although her husband did not come with her. This put a strain on the small household's resources and, although their relatives and her husband helped, they had to go round to maintain contact to this end as well as to do the work associated with child-birth so that their field work suffered. If he had used forethought it would have been possible for him to have got out of this predicament by getting his son-in-law to provide more assistance, or by storing extra food, but this would be quite exceptional and it must be accepted that this man has been beaten by circumstance beyond his control.

SOCIAL REASONS

Any agricultural implement has a maximum amount of work which can be done with it in any given period. Some immigrants occupy new valley land using narrow-bladed axes and short hoes in wooden handles which cannot clear enough land for their needs in the time available.

Msham was an Mgindo immigrant with these tools which were suitable for the lopped tree fields of the *Brachystegia* woodlands. He occupied valley land which was heavily wooded, and, although he worked extremely hard, he had not felled and burnt enough trees for an adequate *shamba*. If he had bought a broad-bladed axe he might have done better, but living in a tribal environment he was unwilling, even if he had thought of it, to give up the tools in the use of which he had been brought up.

Moslem laws of inheritance, in the majority of cases, result in the subdivision of land which may not have harmful if land is plentiful and the inheritors few in number, but if there is only a small area to be inherited and the deceased had many children the land is subdivided into small portion which are unworkable.

Abdallah had died before his land was fully developed, and when it had been divided between his four sons and seven daughters the portions were too small to attract attention and the fields remained unworked and overgrown. The inadequacy of the inheritance effectively dispersed his family so that no one thought it worthwhile to stay in the area and continue his father's efforts. If he had put his land in trust *wokf*, to be administered by the eldest son for the benefit of all his children, the development of his land would have been permanent reminder of the father's foresight as well as preventing the pernicious results of subdivision.

Inheritance quarrels are often particularly bitter and prolonged and prevent the land from being worked, not only up to the time of any imposed settlement but afterwards as well. Such disputes in any community have a corrosive effect which eats into even the closest family relationship.

Kanura and his half-brothers had fought bitterly over the distribution of their father's estate between the sub-families descended from different wives. A settlement by subdividing the area was reached after the land had lain idle for several years, but the brothers were all afraid of each others' supernatural powers and the land was still deserted.

Again, if the father had had the foresight to put the land in trust the quarrelling would have been over the distribution of the profits from the land which itself would have been worked as a single piece by one brother.

The cycle of customary life contains many potential obligations which have to be fulfilled if the individual is to be in good standing with his family or neighbours. The feasts which formally close the mourning for a family member, or the annual gathering of remembrance, are hard to avoid, as the individual is under a normal obligation to contribute. The failure to contribute might bring about varying degrees of ostracism so that the reciprocities which go far to making life interesting, would not be forthcoming.

Fatuma was a divorced woman who was under a strong obligation to contribute heavily to the mourning feast for her recently dead parents which would take place in the next dry season. As she had no means of earning money, her only way to contribute was to cultivate rice and to make a very acceptable contribution in kind.

This resulted in this woman thinking more of the feast than of cultivation, and the cultivation of rice in a locality which her better judgment should have warned her against, and also because she was cultivating as a last-minute expediency the field was not properly prepared. She harvested very little and felt very embittered at this misfortune which was largely of her own making.

Athumani's father died and he and his brothers decided that they must hold a large funeral celebration in his memory. As they had no ready money they mortgaged the coconut harvest in advance to a trader who would take the nuts from the palms up to the equivalent of money borrowed. The trader was only interested in the nuts and never cleared the plantation, so that when it reverted to Athumani it was almost bush and the palms had ceased to yield well.

ECONOMIC REASONS

A plentiful supply of cheap migrant labourers will always cause their employers to avoid doing any work themselves. Each group of these labourers have work characteristics which become utilized for special tasks, and when the changing pattern of economic life in the interior causes a particular tribe to stay at home there is a corresponding change for the worse in the area which they used to work.

Mwinyimkuu was not too well off but any spare money he could scrape together was used to employ Sukuma men on piece rates to dig up the high ridges which are so good for cassava cultivation and which they were used to digging in their own homes. Improved animal husbandry and cotton cultivation in Sukumaland has completely cut off this group of labourers and the possibility of getting such good ridges dug. Our man will never do such work himself because it has been associated for many years with men whom he considered his social inferiors, so he is left poorer in crops as well as in pocket.

Migrant labourers on non-African estates often open up cultivation nearby in order to supplement their wages, but they abandon the land when they decide to go home, and in the meantime are more interested in getting out a quick harvest than in looking after the land.

Sululu was a Makua sisal labourer who opened up a maize field in the nearest piece of vacant land to his estate camp. He was working on a twelve-month contract and knew that he would only be able to get out one harvest. He cleared thick forest on a steep hillside from the crest down to the bank of a running stream and burnt the dead wood in a fire which destroyed a considerable area beyond his potential field. Although it was decided to prosecute him he left the area before he could be brought to court and even before he had completely harvested.

The result of this occupation was that parts of the hillside slid into erosion and the stream became a sour marsh, so that the next occupier got a poor harvest and abandoned the holding. The short-term occupation of land by migrant labour has bad consequences, because, although the fields may be opened up in accordance with customary law, the full cycle of ownership and occupation which has stood the test of time both socially and ecologically is not completed.

The absentee owner who wishes to get rich in two different occupations at the same time is at a constant disadvantage because he does not supervise the work adequately, with the result that he either gets poor value for his expenditure or tries to get too much done with his money.

Omari was an odd-job headman in a local factory on a good salary and wished to provide for his old age by opening up cultivation some distance from his work place where there was suitable vacant land. He was only able to visit the field at weekends, and neither he nor the female relative whom he had induced to live there were able to supervise or control the migrant labourers who worked intermittently and poorly on the fields. The result of this was that he lost half his maize harvest because the fields were not weeded properly, and he got little back in return for the heavy outlay in clearing the ground.

If he had made up his mind to be either a factory worker or a cultivator he would have been better off in either capacity, but this split-mind is typical of peri-urban workers.

The owners of coco-nut plantations have to undergo the annual expense of employing migrant labourers to clear the grass from around the palms; also the labourers may be hard to find. It is therefore common practice to encourage small groups of migrant labourers to settle on the plantation land which serves the double function of making labour available and in having the grass cleared away without charge when the labourers start their fields.

Wanji and his wife came to the coast as migrant labourers and had built a small hut on Mohammed's land, as they were often employed by him and he had allowed them to open up a small cassava field which was under the coco-nut palms and did not prosper. It was impossible to occupy land in the locality except under these conditions. The couple had therefore become semi-stabilized under poor conditions, where they still had to buy their food and yet could not go far afield in search of more profitable work.

Any form of economic specialization in a locality, or working for wages, may prevent a person from cultivation to the best advantage.

Abdallah was asked to thatch the leaking roof of a large house before the rains, which he agreed to do as he had little food left over from the last harvest and was having to buy most of his supplies from a shop.

When he should have been clearing his field he was thatching, and when he should have been planting he was clearing, so that he had a poor crop with a low harvest. Although he got his thatching money, he was out of pocket again soon by having to buy food.

Ecological Reasons

Vermin destroy large areas of fields and the cultivator and his family must watch at night for pigs and in the day for monkeys and baboons. This load is shared where many families cultivate together, or when there are plenty of children to take their turn during the day.

Mtoo who was a hard-worker with one wife only, chose an isolated area for his new fields as the richness of the soil promised a bigger return for his efforts than the lighter soils which he had cultivated before. As the crops grew he was forced to sleep in the fields to scare off marauding pigs, so that in the day-time he was either asleep or too tired to do a full day's work and his fields suffered from monkeys as well as from inadequate weeding. If he had arranged to move with a few relatives they would have become a mutually protecting group against vermin.

Vermin in some areas may be so persistent as to prevent the cultivation of certain crops. This may cause some individuals to leave, and others may be left to exist on an unbalanced diet through a combination of inertia and malnutrition.

Athumani was a middle-aged man whose wife had died soon after had built a house near to his new fields. Several maize harvests were completely ruined by monkeys, so that eventually he took to cultivating cassava only, which gave him an almost entirely carbohydrate diet and which in turn caused him to take up work away from home in order to get adequate food. If he had moved as soon as he had realized the disadvantage of the area he might have preserved his independence, but now he is in a rut of low yields, poor diet and wage-earning from which he will never free himself.

Most cultivators know the potentialities of any type of soil and vegetation, but there may be considerations which override their judgment of these fundamentals.

Selemani wanted to start a large coco-nut plantation as a form of insurance for his old age and because he had a well-built house and a number of pleasant neighbours. He cleared and planted up land near to his home, but almost all the seedlings died, as indeed had those belonging to his neighbours wherever they had planted in the past.

Juma, who had been settled in the area for a long time and was well-established, wanted to start a coco-nut plantation, but there was no suitable vacant land available near his house. He therefore planted his seedlings in land which was usually waterlogged in the wet season or iron-hard in the dry season and every one of them died.

The Failure of a Small Agricultural Scheme

A non-African estate obtained an area of land for temporary use as a nursery with the agreement of the local chief and his council. The land was cleared of trees, planted up, and in due course returned freshly ploughed and harrowed for the use of the local Africans. The land in this condition had a high value, so that a ballot was held with the names of all the potential cultivators in the nearby village to allocate the parcels of land without quarrelling. Only about a tenth of the land was ever cultivated, and most of this abandoned before harvest; most of these occupants stated that they had abandoned their fields because of the poor soil, which had in the meantime been favourably reported on by an Agricultural Officer for fruit trees and legumes. The area was eventually taken over the Local Authority for a tree plantation before the abandoned land could regenerate into thicket.

The reasons for the failure of this scheme appeared to be as follows:—

When the estate first occupied the land, a local branch of a political party proclaimed that the land was being stolen from the people, regardless of the fact that the agreement of everyone concerned had been obtained first. The secretary put up notices to this effect near to the holding. This bellicosity, which came to nothing, had a residual effect on the minds of the potential cultivators.

The proferring of a free gift associated with the work of a non-African estate gave rise to a lot of suspicion, not only as to the real intentions behind the gift but also because the harvest might be seized or ploughed under to plant sisal. Local relations with this estate had always been good, but the emergence of national politics had eroded this even though there had been no disputes. Some of this suspicion might have been removed if the manager had been invited to attend the public meeting in which the use of the vacated land was discussed.

Customary law provided for the occupation of vacant land in various ways, none of which allowed for the vacation of land by an estate and its immediate reoccupation by local cultivators. Cultivators are just are conservative as other people, and confronted with this new situation they were doubtful as to who would be the real owner of the land. A letter from the chief giving each man his entitlement might have helped, and it might have been arranged for each cultivator to be present at the harrowing of his own field to give him a greater sense of individual participation.

The land was made available too late in the year for potential cultivators to fit these fields into the family plan for the coming rainy season. The result of this was that several cultivators were physically unable to work both fields and they naturally neglected the gift field of unknown potential in preference to fields of their own selection. The fields were at one end of the village area, and some of those allocated fields already had holdings at the opposite extremity, which made it impossible even with a bicycle, if not undesirable, to work both fields. The fields should have been allocated about six months before the main rains.

The ballot for the fields organized to avoid quarrelling resulted in fields being allocated to people who had indifferent records as cultivators, or who had no real intention of cultivating at all if they could find any alternative temporary means of livelihood. The ballot ought to have been confined to those whom the chief was convinced would cultivate.

After the allocation, and before cultivation, the news reached the village of the high wages being paid in harvesting the clove crop on the island of Pemba. This resulted in about a quarter of the men leaving the village for several months, including some of the men who had been allocated these fields. Such an occurrence is outside the scope of any reasonable planning but would nevertheless have been quite sufficient to wreck any comparable scheme without any other considerations.

Several of the cultivators observed that the land had been cleared and harrowed and thought that they would not have to start work so early. They badly misjudged their timing and were still breaking up the soil lumps and clearing grass when the main rains came, which should have found them with crops in the seedling stage. It should have been realized that the use of machinery for agriculture was only theoretically known to these people, and some instruction should have been given to them in the practical consequences of such mechanization. The opinion of the rest of the village that these people were just lazy is a far too facile explanation of their failure.

Although it was realized that the mechanized clearing of the land would do away with most of the man's work in a married family and that this might cause trouble, it was not related to local conditions. In the area very few husbands and wives cultivate together because of mutual suspicion and the frequency of divorce. If the offer had been extended to women who have to employ migrant labourers for the clearing of new fields it is probable that the land might have been fully used.

The agricultural cycle has its ritual aspect which is of supreme importance to the cultivator. This land had been opened up without any of the necessary magical precautions which would have accompanied normal ownership. It was possible therefore that the prospective occupiers would have regarded this land as a bad venture even if many of the other factors had been in its favour.

The last and possibly most important drawback was that the land itself, when handed over, was in effect the left-overs from another scheme, and that the land and locality was not therefore suited to the crops most desired by the inhabitants nor geographically well-situated.

CONCLUSIONS

The number and variety of these non-agricultural reasons for failure to succeed underline the importance of trained agriculturists and government officials if their schemes run against the grain of the society on which they are being implemented.

The new agricultural teacher, approaching his work after several years scientific training, can easily be disillusioned and defeated by the complexity of the society which rejects his well intentioned, practical and sound advice.

This complexity also stresses the practical futility of blanket agricultural schemes over both large and small areas, which involves heavy government expenditure and political agitation, without first initiating pilot schemes and having a certain measure of luck.

The fact that a certain crop can grow well in certain circumstances outside society is no guarantee that it will be grown within society. The scheme described here failed because its so-called obvious benefits seemed to preclude the necessity for planning, which might have resulted in at least some of the depressing factors being modified.

REVIEWS

THE AGRICULTURAL REGISTER (New Series): Changes in the Economic Pattern, 1956/57; published by the Agricultural Economics Research Institute, Oxford, 1957, 234 pp., price 21*s*.

The title of this series is misleading in that it suggests a list of names and addresses of farmers. In fact it is a discussion of the development of agriculture in the United Kingdom in relation to Government policy, the present position in regard to the marketing of livestock, livestock products, crops, fruit and vegetables, and the economic relationships between agriculture and imports, labour, land and capital. While the book deals exclusively with agriculture in the United Kingdom, younger countries have much to learn from the accumulation of economic experience on which the discussion is based, and from this aspect the book is of general interest.

D.W.D.

A REVISED LIST OF KENYA GRASSES (with keys for identification), by A. V. Bogdan, published by the Government Printer, Nairobi, 1958, 81 pp., 78 figs., price Sh. 5.

This second edition by Mr. A. V. Bogdan of his *List of Kenya Grasses* will be a welcome addition to the libraries of all who are interested in identifying grasses. There are a total of 463 species described in the keys, and mention of several others which unfortunately did not come to the author's notice in time for inclusion. The book has thus been expanded by some 60 species, many of these coming from the drier grassland areas and Northern Frontier Province.

More illustrations, too, have been added, doubling the number of pages of line drawings. The additional drawings are of a number of the more characteristic spikelet types; so that in tribes such as the Zoysieae and Pappophoreae most of the genera can more easily be recognized from these drawings than from the keys.

This booklet will be of great use in Tanganyika and Uganda as well as Kenya, though it will be necessary to remember that as one gets further away from Kenya the likelihood of meeting species not included increases, and greater discretion in the use of this booklet will be required.

D.M.N.

A STUDY OF THE APHIDIDAE (HOMOPTERA) OF EAST AFRICA, by V. F. Eastop, published by Her Majesty's Stationery Office, London, 1958, 126 pp., 63 figs, price 27*s*. 6*d*.

The identification of pests and diseases of agricultural importance is a task of prime importance in any branch of agricultural pathology. Each year as more and more pathogenic species are described and synonymized the apparently simple task of identification becomes increasingly difficult, and falls more and more into the field of the specialist.

One such specialist, Dr. V. F. Eastop, was awarded a Colonial Research Fellowship in 1952 to make a systematic study of the aphid fauna of East Africa. This book is the culmination of two and a half years' work in East Africa, during the course of which some 80 specimens were found and for which a detailed key was indicated. Being largely a key to the East African species, such a reference work can have little popular appeal, yet with it the entomologist, and some farmers, should be able to identify most of the species encountered and in consequence their host plants and their ability to transmit plant virus diseases, to which considerable economic importance attaches. Notes on collecting and preserving aphids are included together with an ample bibliography for those wishing to pursue the subject further.

A.G.W.

REVIEW

Dairy Produce, 1957.—Obtainable from H.M. Stationery Office or from the Secretary, Commonwealth Economic Committee, 2 Queen Anne's Gate Buildings, Darmouth Street, London, S.W.1, price 5*s*. (5*s*. 9*d*., post free).

World production and exports of dairy produce have continued to increase and export prices have declined substantially, according to this review issued by the Commonwealth Economic Committee. One of the biggest gains has been recorded in the United Kingdom, the principal importing country; United Kingdom production now covers about half of the country's total requirements of milk and milk products, including all of the milk sold for liquid consumption and about half of the cheese, while condensed milk output more than satisfies domestic requirements and, in fact, a large export trade has been developed.

Butter

A recovery in world butter production in 1956 has been followed by a further improvement in output and exports in 1957, which appear to have been nearly as great as in 1950, the peak post-war year. Shipments from Commonwealth countries in 1957 have reflected the lower production of the 1956–57 season, and those from Denmark have continued their downward trend, but substantial surpluses have been exported from a number of other countries, including the Irish Republic, Sweden and Finland at prices below those prevailing on domestic markets. The rise in butter exports in the last three years is illustrated in Table I.

Table I

Exports of Butter from Certain Countries (Thousand Cwt.)

	1955	1956	1957 forecast
New Zealand	3,111	3,263	3,100
Australia	1,627	1,661	1,150
Irish Republic	27	14	300
Denmark	2,545	2,376	2,300
Netherlands	876	621	800
Finland	—	217	500
Sweden	73	331	550
Argentine	220	310	320
Total	8,479	8,793	9,120

The bulk of the increased butter exports has found its way to the United Kingdom, not only the world's principal importer but also virtually the sole importing country to permit imports without restriction of quantity. Increasing imports into the United Kingdom have been reflected in falling prices and a rise in butter consumption at the expense of margarine. In 1956 butter consumption in the United Kingdom was estimated at about 15½ lb. per head, 1 lb. more than in the previous year, margarine consumption declining by 1 lb. to 17 lb., while in 1957 butter consumption has exceeded that of margarine for the first time in post-war years.

Cheese

The Commonwealth increased its share of world cheese production in 1956, following a record output in the United Kingdom, now the largest Commonwealth producer, but its share of cheese exports declined to about 30 per cent compared with nearly one-half in 1938 when Canada was the world's third largest exporter. A further increase in United Kingdom production in 1957 has been reflected in a sharp decline in prices to the lowest levels since 1951.

Milk Powder

Commonwealth countries have shared fully in the marked growth in world production of skimmed milk powder in recent years, both New Zealand and the United Kingdom establishing record levels of output in 1956, but their share of world trade has been declining following the marked increase in United States shipments. Most of these, however, have been of a non-commercial nature, including large free donations for welfare purposes, so that the Commonwealth's share of normal commercial trade is probably not much less than one-half.

Assistance to the Dairy Industry

The Governments of nearly every country provide some form of assistance to milk producers, either in the form of deficiency payments, as in the United Kingdom, or by other measures, such as control of imports and storage programmes which are designed to maintain producer prices at desired levels and which are commonly employed in Continental Europe, or by fixing support prices at which official agencies are prepared to buy dairy products offered to them, as in Canada and the United States. Measures of assistance of this kind are analysed in an Appendix which includes an account of the relevant sections of the Rome Treaty establishing the European Common Market and of the measures at present employed to assist the dairy industries of the six participating countries (France, Italy, Western Germany, Belgium, Luxembourg and the Netherlands). These countries, which in 1956 were net importers of butter to the extent of over 30,000 tons and had a small export balance in their cheese trade, intend to establish common import duties in respect of imports from the rest of the world and managed markets for the main agricultural products.

REVIEWS IN BRIEF

Bois Tropicaux, published by Le Centre Technique Foresties Tropical, Avenue de la Belle-Gabrielle, Nogent-sur-Marne (Seine), France.

The main part of this 86-page booklet consists of descriptions and uses of 60 timber trees which occur in West Africa. One section summarizes the characteristics required in wood which is to be used for special purposes such as house-building, furniture, or boat-building, and gives the names of trees which are suitable for these.

Tractors for Logging. F.A.O. Forestry Development Paper No. 1, published by F.A.O., Rome, 1956, 189 pp., 83 figs., price 10*s*.

This comprehensive review of the subject will be of interest to sawmillers who do their own logging and extraction. Theoretical as well as practical aspects are considered, and methods of extraction are described.

Tools and Equipment for Planting and Reforestation. Information Paper No. 3, Forestry Division, F.A.O., Rome, 1957, 33 pp. (mimeographed), 60 plates.

This booklet describes mechanical and hand implements which are used in preparing the ground and in actual planting. Although the methods are taken from forestry practice in temperate climates the principles apply in the tropics.

Treatment of Fence Posts by the Double Diffusion Process, Forestry Equipment Note No. E.11.57, F.A.O., Rome.

Although no pressure is used, remarkably good penetration is obtained by soaking the fence posts in 7½ per cent copper sulphate solution for two days, then in 7 per cent sodium chromate solution for one day. Insoluble copper chromate is formed in the wood, and the posts are said to be resistant to termite attack. The difficulty is that sodium chromate is classed by shipping companies as a hazardous chemical and is very difficult to obtain outside its country of manufacture.

Flora of Tropical East Africa: Polygonaceae by R. A. Graham, price 3*s*.; Alangiaceae by B. Verdcourt, price 8*d*.; Gymnospermae by R. Melville, price 2*s*., published by the Crown Agents for Oversea Governments and Administrations, London, February–March, 1958.

Three further small parts of this flora appeared during February and March, 1958, dealing with between 50 and 60 species. The revision of the Polygonaceae will be helpful since many species in this family are troublesome weeds. The subdivision of *Oxygonum* into rather numerous species will probably not meet with universal approval. Dr. Melville thoroughly sorted out the important timber genus *Podocarpus* in connexion with this flora and also described two startling new forms of *Encephalartos*, recently discovered in Kenya and Tanganyika. Only two Alangiaceae occur in East Africa and one is recorded for the first time; neither produce timber of any value.

Proceedings of the British Society of Animal Production, 1958, published by Oliver and Boyd, Edinburgh, price 15*s*.

This issue contains 11 papers dealing with breeding, feeding and carcass quality of beef cattle, dairy cattle, and sheep.

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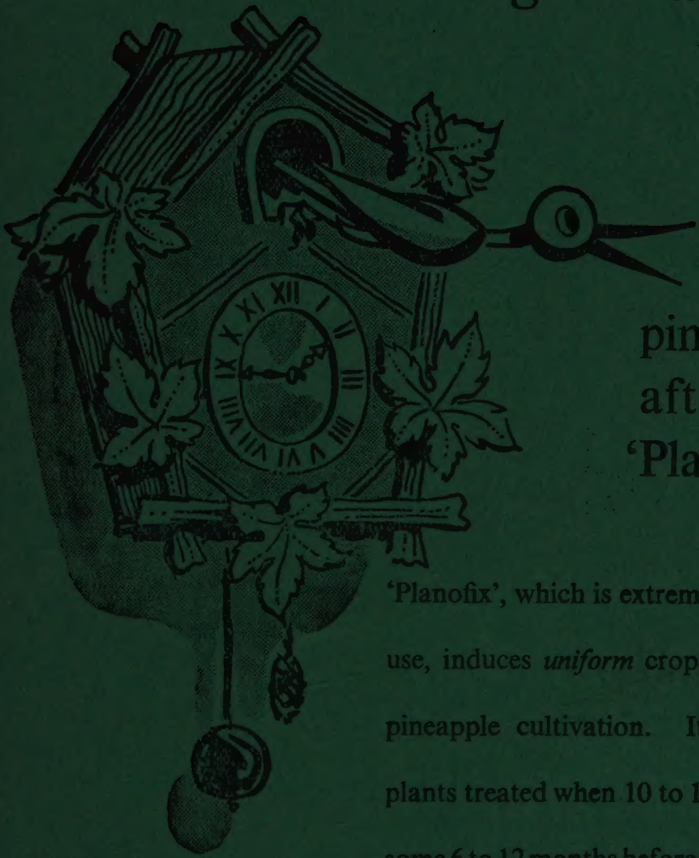

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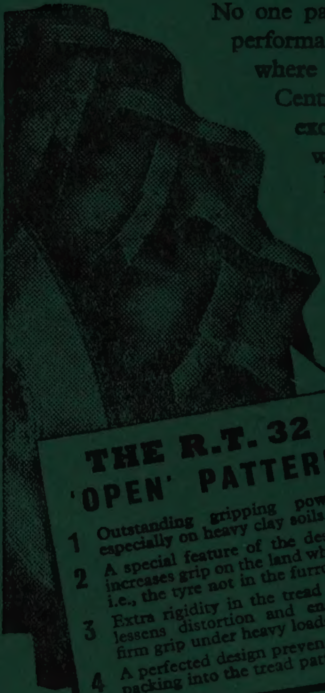

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